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# Stock Assessment of Georges Bank Yellowtail Flounder for 2006

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## ABSTRACT

The combined Canada/US yellowtail flounder (*Limanda ferruginea*) catch decreased from 2004 (7,275 mt) to 2005 (4,150 mt) due to both a decrease in quota and the inability of Canadian fishermen to fill their portion of the quota. Spawning stock biomass has decreased recently, and is currently low at about 5,400 mt, indicating that more stock rebuilding is needed. Recruitment improved during the early 2000s compared to the period 1980 to the mid 1990s, but is now returning towards those levels, averaging 16 million age-1 fish during the past five years. Fishing mortality for fully recruited ages 4+ has been close to or above 1.0 between 1973 and 1994, declined to less than 0.6 in 2002 and 2003, well above the reference point of $F_{ref} = 0.25$, spiked upwards in 2004 to above 1.0, but is still well above the $F_{ref}$ level. Truncated age structure in the surveys and change in distribution indicate current productivity may be limited relative to historical levels. Assuming a 2006 catch equal to the 3,000 mt quota, a combined Canada/US yield of about 1,250 mt in 2007 has a neutral risk, about 50%, of exceeding $F_{ref} = 0.25$.



## RÉSUMÉ

Les prises combinées de limande à queue jaune (Limanda ferruginea) du Canada et des États-Unis ont été moins importantes en 2005 (4 150 tonnes métriques) qu'en 2004 (7 275 tm) en raison d'une baisse du quota et de l'incapacité des pêcheurs canadiens de capturer leur part du quota. La biomasse du stock de reproducteurs a diminué récemment et est actuellement faible (environ 5 400 tm), ce qui indique que le stock doit se rétablir davantage. Le recrutement a augmenté au début des années 2000, mais il retourne maintenant vers les niveaux observés du début des années 1980 au milieu des années 1990, le nombre moyen de poissons d'âge 1 se chiffrant en moyenne à 16 millions au cours des cinq dernières années. La mortalité par pêche parmi les âges pleinement recrutés (4+) a été presque égale ou supérieure à 1,0 entre 1973 et 1994. Elle a ensuite chuté à moins de 0,6 en 2002 et en 2003, ce qui est supérieur au niveau de référence de 0,25, puis elle a monté en flèche en 2004 pour dépasser 1,0, et elle est encore de beaucoup supérieure au niveau de référence. La structure par âge tronquée dans les relevés et les variations sur le plan de la distribution indiquent que la productivité actuelle pourrait être limitée par rapport aux niveaux historiques. Dans l'hypothèse où les prises combinées en 2006 sont égales au quota de 3 000 tm, le risque que des prises combinées d'environ 1 250 tm en 2007 entraînent un taux de mortalité par pêche supérieur au niveau de référence (0,25) serait d'environ 50 %.

## INTRODUCTION

The Georges Bank yellowtail flounder *(Limanda ferruginea)* stock is a transboundary resource in Canadian and US jurisdictions. This paper updates the last stock assessment of yellowtail flounder on Georges Bank, completed by Canada and the US (Stone and Legault 2005) taking into account advice from the 2005 benchmark review (TRAC 2005). A primary objective of the benchmark review was to address the retrospective pattern that had been apparent in assessments conducted during the past several years. During the benchmark assessment meeting, several analytical models were reviewed, all of which revealed differences between the catch at age and survey abundance at age which could not be reconciled. Various possible reasons for the retrospective pattern were identified including an increase in natural mortality, large amounts of unreported catch, and changes in survey catchability since 1995. The consensus view from the benchmark meeting was that management advice should be formulated on the basis of results from several approaches:

- Analysis of data from the surveys and fishery (trends in relative F and Z)
- Base Case VPA model formulation from the 2004 assessment
- Two new VPA model formulations with minor & major changes to Base Case

The analytical methods used in the current assessment are based on revised model formulations adopted during the 2005 TRAC benchmark review using updated information from both countries on catches and survey indices of abundance.

Last year, the two VPA models both indicated that fishing mortality had sharply increased in 2004 and that stock rebuilding was needed. While there was uncertainty about which model was best to use, concordance between the results from the two models (Base Case and Major Change) gave more confidence in the determination of stock status than in the 2004 assessment. Under both VPA formulations, projections indicated that catching the TAC of 6,000 mt in 2005 would result in a fishing mortality rate above $F_{ref} = 0.25$. Given the uncertainty both between and within models, the catch quota for 2006 was set by the TMGC at 3,000 mt.

Yellowtail flounder range from southern Labrador to Chesapeake Bay and are typically caught at depths between 30 and 70 m. A major concentration occurs on Georges Bank from the northeast peak to the east of the Great South Channel. Yellowtail flounder have previously been described as relatively sedentary, although a growing body of evidence counters this classification with off bottom movements (Walsh and Morgan 2004; Cadrin and Westwood 2004), limited seasonal movements (Royce et al. 1959; Lux 1963; Stone and Nelson 2003), and transboundary movements both east and west across the Hague Line (Stone and Nelson 2003; Cadrin 2005). On Georges Bank, spawning occurs during late spring and summer, peaking in May. Eggs are deposited on or near the bottom and after fertilization float to the surface where they drift during development. Larvae are pelagic for a month or more, then become demersal and settle to benthic habitats. Based on the distribution of both ichthyoplankton and mature adults, spawning occurs on both sides of the Hague Line. Growth is sexually dimorphic, with females growing at a faster rate than males (Lux and Nichy 1969; Moseley 1986; Cadrin 2003). Yellowtail flounder have variable maturity schedules, with age two females 40% mature during periods of high stock

biomass to 90% mature during periods of low stock biomass based on analysis of NEFSC spring survey catches.

Historical and new information pertaining to the current management unit for the Georges Bank yellowtail flounder stock was reviewed during the 2005 benchmark assessment. Tagging data, larval distributions, vital population parameters (i.e. growth, survival, recruitment, reproduction, abundance), and geographic patterns of landings and survey data indicate that Georges Bank yellowtail flounder comprise a relatively discrete stock, separate from those on the western Scotian Shelf, off Cape Cod and southern New England (Royce et al. 1959; Lux 1963; Neilson et al. 1986; Begg et al. 1999; Cadrin 2003; Stone and Nelson 2003). Based on information from a comprehensive review by Cadrin (2003) and recent results from cooperative science/industry tagging programs conducted by Canada and the US, there does not appear to be any justification for redefining the geographic boundaries of the Georges Bank yellowtail flounder stock management unit.

The management unit currently recognized by Canada and the US for the transboundary Georges Bank stock includes the entire bank east of the Great South Channel to the Northeast Peak, encompassing Canadian fisheries statistical areas 5Zj, 5Zm, 5Zn and 5Zh (Fig. 1a) and U.S. statistical reporting areas 522, 525, 551, 552, 561 and 562 (Fig. 1b). Both Canada and the US employ the same management unit. The quota sharing agreement between the two countries requires that catches from all sources be counted against the national allocations, regardless of whether the catch was landed or discarded.

## THE FISHERIES

Exploitation of the Georges Bank stock began in the mid-1930s by the US trawler fleet. Landings (including discards) increased from 400 mt in 1935 to 9,800 mt in 1949, then decreased in the early 1950s to 2,000 mt in 1956, and increased again in the late 1950s (Fig. 2). The highest annual catches occurred during 1963-1976 (average: 17,500 mt) and included modest catches by foreign fleets (Table 1). No foreign catches of yellowtail have occurred since 1975. In 1985, the decision was made to manage the stock as a transboundary resource in Canadian and US jurisdictions. Catches averaged around 3,500 mt between 1985 and 1994, then dropped to a record low of 1,183 mt in 1995 when fishing effort was markedly reduced to allow the stock to rebuild. The US fishery in the management area has been constrained by spatial expansion of Closed Area II in 1994 (Fig. 1b) and by extension to year-round closure in 1995, as well as mesh size and gear regulations and limits on days fished. In 2004, a Yellowtail Special Access Program (SAP) in Closed Area II allowed the US bottom trawl fishery short-term access to the area for the first time since 1995. This SAP did not continue in 2005. A directed Canadian fishery began on eastern Georges Bank in 1993, pursued mainly by small otter trawlers (< 20 m). Catches by both nations (including discards) have steadily increased (with increasing quotas) from a record low of 1,183 mt in 1995, when the stock was considered to be in a collapsed state, to 7,857 mt in 2001. In 2004, combined catches for the US and Canada were 7,275 mt, with the US catching its portion of the quota but Canada unable to do likewise. In 2005, the US nearly

attained its quota but Canada caught only 20% of their quota (most of which were discards), resulting in a total catch of 4,150 mt.

**United States**

The principal fishing gear used in the US fishery to catch yellowtail flounder is the otter trawl, although scallop dredges account for some landings. In recent years, otter trawls have accounted for more than 98% of the total USA landings of Georges Bank yellowtail, while dredges have accounted for 0-2%. US trawlers that land yellowtail flounder generally target multiple species. Current levels of recreational fishing are negligible and there have been no foreign catches since 1995.

In May 2004, a new electronic dealer reporting system was implemented in the Northeast for US landings. This new reporting system did not allow the typical proration to stock area scheme using logbook data as described in Cadrin et al. (1998) because neither the area fished nor gear code was included in many of the dealer records. Gear codes were assigned to permits that had only used a single gear based on logbook records. This allowed the typical proration scheme to be used. Examination of patterns of landings reported in the dealer database and those in the logbook records show similar trends in terms of time of year, gear, and port. Thus, there is no indication of a systematic bias in these allocations. Total yellowtail landings (excluding discards) for the 2005 USA fishery were 3,327 mt, a decrease of 46% from 2004, but comparable to landing in the early 2000s (Table 1; Fig. 2).

Total discards of yellowtail in the US fishery decreased slightly from 548 mt in 2004 to 476 mt in 2005. This reduction was due to the decline in trawl discards, even though dredge discards increased. Discarding of yellowtail in the US trawl fishery decreased in 2005 due mainly to a decrease in landings. Conversely, the scallop dredge landings of scallops were near the record high in 2005 causing an increase in discarding of yellowtail. In 2005, 42% of yellowtail discards originated from the trawl fishery (199 mt), while the majority (58%) came from the scallop fishery (277 mt). The trawl fishery estimates of discards were obtained from discard to kept (d:k) ratios of yellowtail derived from observer data. Comparison of d:k ratios from observers and logbooks indicated that logbook values were slightly lower than observer values for similar time periods, but show the same pattern. In 2005, the scallop dredge fishery had two Special Access Programs on Georges Bank, one in Closed Area I and the other in Closed Area II, which generated an increase in scallop landings. Due to the negligible landings of yellowtail in the scallop fishery, the d:k ratio of yellowtail could not be applied. The observed scallop landings were well beyond the values used in the benchmark regression method to estimate discards of yellowtail from scallop landings, and more importantly, the scallop landings from CAI had a much lower discarding rate of yellowtail than in other areas. Application of a d:k ratio approach using yellowtail discards and scallop kept from observed trips in the two SAPs and the regression approach for scallop landings in open areas produced the best estimate of yellowtail discards (277 mt) in the USA scallop fishery on Georges Bank.

The total US catch of Georges Bank yellowtail in 2005, including discards, was 3,803 mt. The US Georges Bank yellowtail quota for fishing year 2005 (1 May 2005 to 30 April 2006) was 4,260 mt. Monitoring of the US catches relative to the quota was based on Vessel Monitoring Systems (VMS) and a call-in system for both landings and discards. The assessment

methodology and the monitoring methodology to estimate landings and discards were compared for the six month period July 1 to December 31 2005. During this period, the assessment estimated catch was 2,179 mt while the monitoring estimated catch was 2,311 mt (6% more). This match is closer than during July-December 2004 when the monitoring catch was 13% lower than the assessment catch.

**Canada**

Canadian fishermen initiated a directed fishery for yellowtail flounder on Georges Bank in 1993. Prior to 1993, Canadian landings were low, typically less than 60 mt (Table 1, Fig. 2). Landings of 2,139 mt of yellowtail occurred in 1994, when the fishery was unrestricted. After a TAC of 400 mt was established, yellowtail landings dropped to 464 mt in 1995. Subsequently, both quotas and landings increased and in 2001 were 2,913 mt. The majority of Canadian landings of yellowtail flounder are made by otter trawl from vessels less than 20 m, tonnage classes 1-3. The Canadian fishery generally occurs from June to December, with most landings in the third quarter. In 2004, landings were 96 mt (against a quota of 1,900 mt). Unlike other years, Canadian fishermen were unable to find commercial quantities of yellowtail in 2004 and the directed fishery ceased in September. In 2005, landings were 30 mt (against a quota of 1,740 mt) as again Canadian fishermen were unable to find commercial quantities of yellowtail (Table 1). Most of the yellowtail landings reported for 2005 were from trips directed for other groundfish species (i.e. cod, haddock).

Flatfish landed as "unspecified" in the Canadian fishery have been significant in previous years, and on Georges Bank generally consist of yellowtail. Neilson et al. (1997) revised the landings data for the early years of the fishery (1993-1995) to account for catches of unspecified flounder species. The unspecified flounder problem has become less significant recently, due to improved reporting practices. Total unspecified flounder landings in 2005 estimated to be yellowtail, were 0.8 mt for 5Zj, and are included as part of the Canadian landings (Table 1).

The Canadian directed fishery for yellowtail has traditionally been concentrated in the southern half of the Canadian fishing zone, in the portion of 5Zm referred to as the "Yellowtail Hole" (Fig. 3). In 2004 and 2005, the geographic distribution of catches expanded outside the Yellowtail Hole area (5Zm) into 5Zj, but catches were small (average = 60 and 28 kg/tow for 2004 and 2005, respectively) and were mainly bycatch from cod and haddock directed trips.

The Canadian offshore scallop fishery is considered to be the main source of Canadian yellowtail flounder discards/bycatch on Georges Bank. As a result of the recent benchmark review, these data are now incorporated into the Canadian fishery catch and catch at age for 1973 onward. Prior to 1996, landing of groundfish bycatch by the Canadian scallop fishery on Georges Bank was allowed; however, not all the yellowtail flounder bycatch was landed. To account for the total bycatch for 1973-1995, it was necessary to augment the yellowtail landings by the scallop fishery with the yellowtail discarded. Management measures established in 1996 prohibit the landing of groundfish (except monkfish) by the Canadian scallop fishery and all bycatch of yellowtail flounder is now discarded. Discards, whether pre or post 1996, are not recorded in the Canadian fishery statistics and can only be estimated from observer deployments.

Prior to 2001, very few Canadian scallop trips on Georges Bank had at-sea observer coverage; only nine trips were monitored from 1991 to 1998. In response to a Fisheries Resource Conservation Council recommendation, a monitoring program of the Canadian offshore scallop industry was conducted in 2001 and 2002 to gather data on bycatches. Twelve trips were observed which covered all months except January and October. In August 2004, routine observer coverage was initiated on vessels in the Canadian scallop fishery on Georges Bank. A total of 5 trips were observed in 2004 and 11 trips in 2005.

Van Eeckhaute et al. (2005) provide the methodology used for estimating yellowtail flounder discards in the Canadian scallop fishery during 1960-2004 based on observer data (although for yellowtail, estimates are required only since 1973). For 1996-2004, when yellowtail flounder landings were not permitted, effort in the scallop fishery was prorated by the observed discard rate of yellowtail to effort to obtain an estimate of discards. While the available data do not support any unit area trends in discard rates, higher discard rates occur in April, May and June and lower discard rates in November and December. Therefore, the proration was conducted using discard rate by quarter. Quarterly discard rates for periods when no observed trips were available were derived by interpolation and application of a seasonal pattern. To estimate discards for year 1996 and later, the quarterly discard rates were applied to the total quarterly effort of the scallop fleet. This approach was applied to the 2005 observer data to provide an estimate of 317 mt of yellowtail discards. For 1973-1995, the number of observed trips was very limited and the ratios were subject to influence by anomalous outliers. An effort-based proration was used without seasonal factors because of the limited information available for this period. The approach used for both periods depends on the assumption that the bycatch population density, i.e. the *discard+landed / scallop effort* ratio for observed scallop fishing is representative of that for the scallop fishery, as well as on the assumption that discarding practices are representative.

Discard estimates from 1973-2005 averaged 538 mt and ranged from a low of 268 mt in 1995 to a high of 815 mt in 2001 (Table 1). When Canadian yellowtail flounder catches are revised to include the discard estimates from the offshore scallop fishery, the annual quotas during 1994 to 2003 are exceeded in all years by an average of 440 mt (range: 251-683 mt). For 2005, the total Canadian catch including estimated discards was 347 mt, down 33% from 2004 and well below the 2005 TAC of 1,740 mt.

**Length and Age Composition**

In 2005, 394 length measurements were available from 3 port samples from the Canadian fishery (181 males and 213 females (Table 2) which were used to characterize the Canadian catch size composition by sex. Although additional length measurements were available from one at sea observer deployment ($n$ = 280), these were not used because of apparent error in sex determination.

The number of US port samples increased in 2005, with 8,295 length measurements available from 81 samples, even though US yellowtail landings declined by about 50% from 2004 (Tables 1-2). This compares with 7,964 measurements from 74 samples in 2004. The 81 port samples also provided 1,798 age measurements for use in age-length keys. At-sea sampling also

increased in 2005 and provided an additional 40,578 length measurements, which were combined with the port samples to characterize the size composition of the US catch.

US landings are classified by market category (large, small, and unclassified) and these categorizations are used in determining size and age distributions. Both the amount and the proportion of yellowtail landed in the large market category have increased since 1995 (from approximately 50% to approximately 75%) although the 2005 proportion was only 63%. Examination of the size distributions of the two market categories continues to show some overlap in the 35-40 cm range, but overall discrimination between the groups (Fig. 4). The proportion of the landings in the large market category that are 45 cm and larger increased during 2000 to 2004; 5%, 8%, 12%, 22%, 20%, respectively, but declined to 7% in 2005.

The size composition of yellowtail flounder discards in the Canadian offshore scallop fishery was estimated by half year using length measurements obtained from 11 observed trips in 2005. These were prorated to the total estimated bycatch at size using the corresponding half year length-weight relationship and the estimated half year bycatch (mt) calculated using the method of Stone and Gavaris (2005). Discards at age by half year were then obtained using half year age length keys based on the following combined ages: Half 1 US commercial fishery + NMFS spring survey, and Half 2 US commercial fishery + NMFS fall survey.

US discard length frequencies were generated from observer data, expanded to the total weight of discards by gear type and half year. First half year trawl discards contained many legal sized fish due to the prohibition of landings early in the year, while discards in the second half of the year were mostly due to minimum size culling (Fig. 5). Dredge discards were low in the first six months and similar in size distribution to the second half discards, in that most discards were legal sized fish as has been typically seen for dredge gear in the past (Fig. 5).

A comparison of the size composition of yellowtail catch by country, revealed that the Canadian fishery (landings plus discards) has had a higher proportion of smaller-sized fish than the US fishery (landings plus discards) since 2002 (Figs. 6-7).

Although otoliths are used to determine ages for Grand Bank yellowtail (Walsh and Burnett 2001), age determination of Georges Bank yellowtail flounder using otoliths is hampered by the presence of weak, diffuse or split opaque zones and strong checks, which often make interpretation of annuli subjective and difficult (Stone and Perley 2002). Therefore, scales are the preferred structure for aging Georges Bank yellowtail. Percent agreement on scale ages by the US readers continues to be high (>85% for most studies) with no indication of bias (J. Burnett, NMFS, TRAC Working Paper, 2006).

In 2004, a total of 70 male and 92 female ages were available from the Canadian fishery and were used to construct the catch at age (CAA) by sex for the 2004 Canadian commercial fishery. No scale samples were available for the Canadian fishery in 2005. Therefore, age samples from second Half US port sampling and the NMFS fall survey were used to construct the catch at age by sex for the 2005 Canadian landings.

For the US fishery, sample length frequencies were expanded to total landings at size using the ratio of landings to sample weight (predicted from length-weight relationships by season; Lux 1969), and apportioned to age using pooled-sex age-length keys in half year groups. Landings were converted by market category and half-year, while discards were converted by gear and half year.

In 2005, ages 2, 3, and 4 (2003, 2002 and 2001 year classes, respectively) dominated both the Canadian and US landings, with age 3 predominant and fewer older fish than in 2004 (Fig. 8). The US fishery had a higher percentage of fish aged 4+ in 2005 than did the Canadian fishery. Since the mid 1990s, ages 2-4 have constituted most of the exploited population, with very low catches of age 1 fish due to the implementation of larger mesh in the cod end of commercial trawl gear (Table 3; Fig. 9).

The fishery mean weights at age for each of the Canadian and US landings and discards were derived using the ALKs, and applicable length frequencies, and length-weight relationships. The mean weight at age (kg) for the Canadian and US landings were quite similar and generally were more variable at older ages (5+) during the mid 1980s to the mid 1990s (Figs. 10 and 11). These were then combined for an overall fishery weight at age, weighting by the respective catch at age (Table 4; Fig. 12). A trend of increasing weight at age is apparent for all ages since 1995, returning to levels seen in the late1970s/early 1980s. Recent weight at age (WAA) values are within the range of past WAA calculations since 1973.

## ABUNDANCE INDICES

### Research Vessel Surveys

Bottom trawl surveys are conducted annually on Georges Bank by DFO in the spring (February) and by the US National Marine Fisheries Service (NMFS) in the spring (April) and fall (October). Both agencies use a stratified random design, though different strata boundaries are defined (Fig. 13). NMFS spring and fall bottom trawl survey catches (strata 13-21), NMFS sea scallop survey catches (scallop strata 54, 55, 58-72, 74), and DFO spring bottom trawl survey catches (strata 5Z1-5Z4) were used to estimate relative stock biomass and relative abundance at age for Georges Bank yellowtail. Conversion coefficients, which adjust for survey door, vessel, and net changes in NMFS groundfish surveys (1.22 for old doors, 0.85 for the Delaware II, and 1.76 for the Yankee 41 net; Rago et al. 1994) were applied to the catch of each tow.

Yellowtail flounder biomass indices from the three groundfish surveys track each other reasonably well over the past two decades. DFO survey biomass indices increased from 1995 to 2001 (the highest value in the series), but have declined since (Table 8; Fig. 14). The current index is still higher than any observed during the mid-1990s when the stock had collapsed. The NMFS spring series tracks the DFO series well during the years of overlap up to 1999, then shows a decline through to 2001 followed by a sharp increase in 2002 (Table 6; Fig. 14). Similar to the DFO series, the NMFS spring biomass index sharply declined from 2002 to 2004 (the lowest value since 1994), increased slightly in 2005, and decreased again in 2006. The NMFS fall survey, which is the longest running time series, also increased from 1995 to 1999, fell

slightly in 2000 followed by a large increase in 2001 (Table 7; Fig. 14). The NMFS fall index showed a strong decline between 2001 and 2002, increased through 2003 and 2004, and then decreased in 2005 to its lowest level since 1996. The NMFS fall index is still at a relatively high level compared to the mid 1990s when the stock was at low levels. Both the NMFS spring and fall survey indices show high inter-annual variability during periods of high abundance (i.e. the 1960s and 1970s) which may reflect the patchy distribution of yellowtail on Georges Bank and the low sampling density of NMFS surveys.

Since 1996, most of the DFO survey biomass and abundance of yellowtail flounder has occurred in Stratum 5Z4, which includes the lower portion of Closed Area II on the US side, where no commercial groundfish fishing was allowed from 1995 through 2003 (Fig. 15). Survey indices for this stratum tend to be quite variable due to low sampling intensity, but show a higher level since 1996 relative to pre 1995. Stratum 5Z2 (CDN portion of Georges < 90 m depth) has also shown an increasing trend in biomass and abundance since 1996, but at a lower level than 5Z4. However, both the 2005 and 2006 surveys indicate that both biomass and abundance have declined within strata 5Z2, despite the very limited Canadian fishery in 2004 and 2005.

The two NMFS surveys cover a longer time period than the DFO survey and show a greater change in spatial distribution of yellowtail on Georges Bank. Both the NMFS Spring and Fall surveys show a large increase in the importance of stratum 16 over time (Figs. 16-17). Stratum 16 contains the lower portion of Closed Area II as well as the "Yellowtail Hole" in Canadian waters. Early in the time series, strata 13 and 19 both contributed substantially to the overall Georges Bank indices for both seasons, but in recent years stratum 16 alone has accounted for approximately 90% of the survey index in both series (Fig. 18). The increase in importance of stratum 16 could be due to an increase in density within Closed Area II, a decrease in density in the other strata, or, more likely, both. This indicates that the resource has become much more spatially concentrated on Georges Bank. Given that recent tagging studies have shown that yellowtail move throughout Georges Bank much more than previously thought (Tallack et al. 2005; see also www.cooperative-tagging.org website), changes in density by strata could also be due to changes in behavior over time.

Average weights at length were examined by sex for three length ranges of yellowtail flounder (29-31 cm, 34-36 cm and 39-41 cm) in DFO surveys conducted during 1987-1991 and 1996-2006 (note: weights were not recorded in the 1992-1995 DFO surveys) (Fig. 19). The mean weights are used to reflect fish condition, which has not appreciably changed until the past few years when the weights have been below average.

Age-structured indices of abundance for NMFS spring and fall surveys were derived using survey-specific age-length keys. In the past, age-length keys from NMFS spring surveys have been substituted to derive age composition for same-year DFO spring surveys, as no ages were available from the DFO surveys because of difficulties associated with age interpretation from otoliths (Stone and Perley 2002). To avoid having to use substituted age data, NMFS personel are now ageing scales collected on DFO surveys. From the 2006 DFO survey, 279 male and 217 female fish were aged and used to produce separate-sex age-length keys subsequently used to generate the 2006 DFO age-specific indices of abundance.

Both the DFO and NMFS spring 2006 survey indices indicate that the 2003 year class (Age 3) dominates the stock and the NMFS spring survey also indicates an unusually large 2005 year class (Age 1) (Tables 5-6; Fig. 20). In contrast, the NMFS fall survey shows that the 2002 year class (Age 3) dominated the stock in 2005 (Table 7; Fig. 20). Overall, survey age-structured indices do not track cohorts well and there are some indications of year-effects within the time series.

The NMFS sea scallop survey is used as an index of "mid-year" age 1 yellowtail recruitment since small yellowtail are a common bycatch in this survey. The time series was updated from the 2005 assessment to include the age-1 index value for 2005. While the 2005 index was higher than in 2004, it is below the time series average (Table 8).

Trends in relative fishing mortality and total mortality from the surveys were examined as part of the consensus benchmark formulations agreed to at the second benchmark assessment meeting in April 2005. Relative fishing mortality (fishery biomass/survey biomass, scaled to the mean for 1987-2005) was quite variable but followed a similar trend for all three surveys, with a sharp decline to low levels in 1995 and a marked increase in 2004 (Fig. 21). In contrast, estimates of total mortality rates from the surveys for ages 2, 3, and 4-6, although noisy, are without trend and indicate no reduction in mortality over time (Fig. 22).

## ESTIMATION OF STOCK PARAMETERS

Results from assessment analyses conducted in recent years have displayed: a) retrospective patterns; b) residual patterns that are indicative of a discontinuity starting in 1995; and c) fishing mortality rates that are not consistent with the decline in abundance along cohorts evident in the survey data. Essentially, the catch at age data and assumed natural mortality rate cannot be reconciled with the high survey abundance indices at ages 2 and 3 and the low survey abundance indices at ages 4 and older.

The empirical evidence suggests that significant modifications to population and fishery dynamics assumptions are required to reconcile the fishery and the survey observations. Models that adopt such modifications imply major consequences on underlying processes and/or fishery monitoring procedures. The magnitude of implied changes to natural mortality rate, survey catchability relationships, and/or unreported catch are so great that the acceptability of models that incorporate these effects is suspect.

In view of these reservations, adoption of a benchmark formulation that incorporated these modifications to assumptions, as the sole basis for management advice was not advocated (TRAC 2005). Therefore the TRAC recommended that management advice be formulated after considering the results from 3 VPA approaches described below.

In the past, two independent sets of software were used for the analyses; the Canadian ADAPT software and the US NFT VPA v2.2.1 software. Results from the two approaches have always been quite similar, but slight differences exist in the minimization routines, treatments of the plus group, and utilization of bias correction. The fishing mortality rate for the 6 plus group was

calculated according to the "alpha" method (Restrepo and Legault 1994) in the Canadian ADAPT software, while an average of fishing mortality on younger ages was used in the US NFT VPA software. Canadian scientists and managers have traditionally utilized bias correction in presentation of results, while US scientists and managers have not (although see the TRAC Proceedings for further discussion). Nonetheless, the results have been so similar between the methods that differences often cannot be seen on graphs, but rather must be observed in tables of results.

Both the Canadian and US software packages use the adaptive framework, ADAPT, (Gavaris 1988) to calibrate the sequential population analysis with the research survey abundance trend results. The model formulation employed assumed that the random error in the catch at age was negligible. The errors in the abundance indices were assumed independent and identically distributed after taking natural logarithms of the values. Zero observations for abundance indices were treated as missing data as the logarithm of zero is undefined. The annual natural mortality rate, M, was assumed constant and equal to 0.2 for all ages. The fishing mortality rates for age groups 5 and 6+ were assumed equal. These model assumptions and methods were the same as those applied in the last assessment (Stone and Legault 2005). Both point estimates and bootstrap statistics of the estimated parameters were derived using only the US software for this assessment.

**1. Base Case VPA**

The Base Case Virtual Population Analysis (VPA) used revised annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages $a$ = 1 to 6+, and time $t$ = 1973 to 2005, where $t$ represents the beginning of the time interval during which the catch was taken. The VPA was calibrated to bottom trawl and scallop survey abundance indices, $I_{s,a,t}$, for:

$s_1$ = DFO spring, ages $a$ = 2 to 6+, time $t$ = 1987 to 2006
$s_2$ = NMFS spring (Yankee 36), ages $a$ = 1 to 6+, time $t$ = 1982 to 2006
$s_3$ = NMFS spring (Yankee 41), ages $a$ = 1 to 6+, time $t$ = 1973 to 1981
$s_4$ = NMFS fall, ages $a$ = 1 to 6+, time $t$ = 1973.5 to 2005.5
$s_5$ = NMFS scallop, age $a$ = 1, time $t$ = 1982.5 to 2005.5

Data were aggregated for ages 6 and older to mitigate against frequent zero observations at older ages. This is the same formulation used since 1996.

**2. Minor Change VPA**

A VPA using the expanded annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages $a$ = 1 to 12, and time $t$ = 1973 to 2005, where $t$ represents the beginning of the time interval during which the catch was taken. The error in the catch at age was assumed to be negligible compared to the error in the survey indices. Natural mortality was assumed to be 0.2 for all ages and years.

The VPA was calibrated to bottom trawl survey indices, $I_{s,a,t}$, for:

$s_1$ = DFO spring, ages $a$ = 4, 5, 6-9, time $t$ = 1987 to 2006

$s_2$ = NMFS spring (Yankee 41), ages $a$ = 4, 5, 6-9, time $t$ = 1973 to 1981
$s_3$ = NMFS spring (Yankee 36), ages $a$ = 4, 5, 6-9, time $t$ = 1982 to 2006
$s_4$ = NMFS fall, ages $a$ = 4, 5, 6-9, time $t$ = 1973.5 to 2005.5
$s_5$ = NMFS scallop, age $a$ = 1, time $t$ = 1982.5 to 2005.5

The aggregated ages 6-9 survey indices were compared to ages 6-9 population abundance. Errors in the indices were assumed to be independent and identically distributed. Relationships between indices and population abundance for all ages were assumed to be proportional. Population abundance at age 1 in the terminal year was assumed equal to the geometric mean over the most recent 10 years. Population abundance in the terminal year was estimated for ages 4-6 where the results were deemed reliable and calculated for ages 7-11 based on a weighted average F for ages 4+. Abundance at ages 2 and 3 in terminal year was based on average PR to fishery for the previous 5 years. The survivors at age 13 in all years were assumed to be few and were set to 1,000 fish.

The Minor Change VPA was not accepted during the 2005 assessment due to a large change in partial recruitment to the fishery for young ages in 2004 compared to the partial recruitment for these age groups in the assessment reviewed at the 2005 benchmark meeting. This problem became even greater this year when parameter estimates were made at the bounds of extremely low stock abundance and extremely high fishing mortality rates. Additionally, estimating younger ages to overcome this problem resulted in stock abundance and fishing mortality trends that were remarkably similar to the Base Case VPA . Since these estimates were only possible by changing the formulation and the results were so similar to the Base Case VPA, they are not considered further.

**3. Major Change VPA**

A VPA using the expanded annual catch at age (including US and Canadian discards), $C_{a,t}$, for ages $a$ = 1 to 12, and time $t$ = 1973 to 2005, where $t$ represents the beginning of the time interval during which the catch was taken. The error in the catch at age was assumed to be negligible compared to the error in the survey indices. Natural mortality was assumed to be 0.2 for all ages and years.

The VPA was calibrated to bottom trawl survey indices, $I_{s,a,t}$, for:

$s_1$ = DFO spring, ages $a$ = 2 to 5, 6-9, time $t$ = 1987 to 1994
$s_2$ = DFO spring, ages $a$ = 2 to 5, 6-9, time $t$ = 1995 to 2006
$s_3$ = NMFS spring (Yankee 41), ages $a$ = 1 to 5, 6-9, time $t$ = 1973 to 1981
$s_4$ = NMFS spring (Yankee 36), ages $a$ = 1 to 5, 6-9, time $t$ = 1982 to 1994
$s_5$ = NMFS spring (Yankee 36), ages $a$ = 1 to 5, 6-9, time $t$ = 1995 to 2006
$s_6$ = NMFS fall, ages $a$ = 1 to 5, 6-9, time $t$ = 1973.5 to 1994.5
$s_7$ = NMFS fall, ages $a$ = 1 to 5, 6-9, time $t$ = 1995.5 to 2005.5
$s_8$ = NMFS scallop, ages $a$ = 1, time $t$ = 1983.5 to 1994.5
$s_9$ = NMFS scallop, ages $a$ = 1, time $t$ = 1995.5 to 2005.5

Splitting the survey time series at 1995 could not be justified based on changes in the survey design or implementation. Rather, the split is considered to alias unknown mechanisms causing

the retrospective pattern in the Base Case VPA. The aggregated ages 6-9 survey indices were compared to ages 6-9 population abundance. Errors in the indices were assumed to be independent and identically distributed. Relationships between indices and population abundance for all ages were assumed to be proportional. This differs from the benchmark assessment where the relationships between indices and population abundance for younger ages (1-3) were power relationships. The power relationships in last year's assessment were close to linear and the current results using linear relationships appear sufficiently different from the Base Case VPA without requiring the additional parameters, so linear relationships were used for all ages. Population abundance at age 1 in the terminal year was assumed equal to the geometric mean over the most recent 10 years. Population abundance in the terminal year was estimated for ages 2-6 where the results were deemed reliable, and calculated for ages 7-11 based on an unweighted average F for ages 4+. The survivors at age 13 in all years were assumed to be 1,000 fish. This formulation did not produce reasonable results due to the very low (zero) catch at ages 9-12 in 2005 (Table 3). These low catches could not be easily reconciled with the catches of these ages in 2004. Bootstrapping produced bimodal distributions with 21% of the estimates at extremely high fishing mortality rates and corresponding low SSB (Fig. 23). Thus, the final formulation was changed to use an age 6 plus group to avoid the problems caused by zero catches at old ages, with the time series still split in 1995. This formulation produced results similar in trend to the benchmark formulation, but did not have the problem of bimodal bootstrap results.

**Diagnostics**

Similar to last year, the population abundance estimates for the Base Case VPA show greater relative error in model fit (54%) and relative bias (10%) for age 2 while the relative error for ages 3-5 is lower (31-38%) and the bias is smaller (4-7%) (Table 9). The population abundance estimates for the Major Change VPA show greater relative error (32% age 2 to 36% age 5) and bias (4% age 3 to 6% age 5) in model fit with increasing age (Table 10). In both models, bias was less than 25% of the standard error for all parameter estimates, indicating that bias correction was not required (Efron and Tibshirani 1993).

Survey calibration constants (q's) for the Base Case VPA decline at the oldest age group (6+) in the DFO survey but continue to increase with increasing age in both NMFS surveys (Table 9). Survey calibration constants (q's) for the Major Change VPA follow this pattern for the pre-1995 period, but all three level off or decline at older ages in the recent period (1995 to present) (Table 10). Comparing the q's for each survey between the two time periods shows a large increase in catchability in the recent period, with some ages increasing more than five-fold and a nearly three-fold average increase (Fig. 24). There have been no changes in the survey design or operations that can explain such changes. These changes in q are considered to be aliasing unknown mechanisms for the sole purpose of producing a better fitting model.

The Base Case VPA continues to show a strong residual pattern in the DFO, NMFS Spring, and NMFS Fall surveys (Fig. 25). There is a large block of positive residuals (observed greater than predicted) over all ages from approximately 1996 to 2003 which is preceded by approximately a decade of mostly negative residuals in each of these surveys. The most recent years in the surveys have a mix of positive and negative residuals. The model is predicting an increase in abundance for all ages in recent years that is leveling off while the survey observations have a strong up then down pattern since 1995. The residual pattern for the Major Change VPA is much

better than the Base Case VPA with more mixed positive and negative residuals, as expected due to splitting the time series in 1995 (Fig. 26). The average magnitude of residuals has also decreased compared to the Base Case VPA, as expected due to the addition of 18 parameters.

Retrospective analysis for the Base Case VPA indicates a strong tendency to underestimate fishing mortality on ages 4+ and to overestimate spawning stock biomass (Fig. 27). Although the magnitude of the retrospective pattern from 2003 to 2004 and especially 2004 to 2005 is less than in previous years, the Base Case VPA continues to display a retrospective pattern, updating population biomass estimates to lower values than previously determined and compromising interpretation of results. Retrospective analysis for the Major Change VPA did not exhibit a consistent retrospective pattern, as updates were both above and below previously estimated values (Fig. 28). The retrospective pattern observed in the Base Case VPA has resulted in decreases to the terminal year spawning stock biomass to lower levels when updated, averaging 37% decrease over the past 5 years (range: 16% to 59% decrease) with the most recent update exhibiting a 40% decrease. In contrast, the Major Change VPA retrospective results have been both positive and negative over the past 5 years, averaging a 14% decrease (range: 47% decrease to 59% increase), with the most recent update exhibiting a 26% decrease.

Trends in age 3+ biomass from the Base Case VPA do not display a decline in recent years as indicated by all three surveys (Figs. 14 and 29) and this model was rejected at the 2006 TRAC meeting as the basis for management advice. The Major Change VPA better reflects the recent decreasing trend observed in all three surveys (Figs. 14 and 29) and was recommended by the TRAC as the basis for management advice.

## STOCK STATUS

### Virtual Population Analysis

Results from the Major Change VPA model formulation were used to evaluate the status of the stock in 2005 (Tables 11-12). The fishery weights at age, assumed to represent mid-year weights, were used to derive beginning of year weights at age (Table 13), and these were used to calculate beginning of year population biomass (Table 14). In the US, spawning stock biomass is the preferred metric for biomass and is computed assuming maturity at age and the proportion of mortality within a year that occurs prior to spawning ($p = 0.4167$).

Beginning of year population biomass (Ages 1+) declined from about 32,000 mt in 1973 to a historic low of about 4,000 mt in 1988, increased through the early 2000s and then declined to 7,999 mt at the beginning of 2005 (Table 14). Age 3+ (adult) biomass followed a similar trend, with a low of 2,000 mt in 1995, an increase through the early 2000s and then decreased to 5,450 mt in 2006 (Table 16). Spawning stock biomass also followed a similar pattern, SSB in 2005 was estimated at 5,441 mt (Fig. 29).

Age 1 recruitment improved during the early 2000s compared to the period 1980 to the mid 1990s, but is now returning towards those levels, averaging 16 million age-1 fish during the past five years (Table 11; Fig. 29). Previous assessments had indicated the presence of some larger

recruitment for these years, but their magnitudes have subsequently been estimated to be much smaller. Current indications for the 2004 year class (estimated at 9 million recruits) indicate that it may be of lower strength than year classes from the past 5 years.

Fishing mortality for fully recruited ages 4+ has been close to or above 1.0 between 1973 and 1994, declined to lows of less than 0.6 in 2002 and 2003, well above the reference point of $F_{ref} = 0.25$, increased in 2004 to above 1.0 and subsequently decreased to 1.4 in 2005 (Table 12; Fig. 30, upper panel). This agrees with the assessment results from last year, but contrasts with the perception of recent fishing mortality below $F_{ref}$ from previous assessments. Noteworthy is that the lack of trend in the total mortality estimates from the surveys (Fig. 22) is not consistent with the VPA results since 1994, while the pattern exhibited by the relative F is similar (Fig. 21). The fully recruited (ages 4+) exploitation rate averaged 62% from 1973-1994, declined in 1995, spiked upwards dramatically in 2004 and in 2005 is estimated at 69%, which is well above the 20% exploitation equivalent to $F_{ref}$ (Fig. 30, lower panel).

## FISHERY REFERENCE POINTS

### Yield per Recruit Reference Points

Although the yield per recruit analysis was not updated this year, an estimate of $F_{0.1}$ for ages 4+ was calculated from the past yield per recruit analysis of Neilson and Cadrin (1998). ($F_{0.1}$ for ages 4+ = 0.25; exploitation rate=20.0%). This is the same value as the $F_{MSY}$ proxy of $F_{40\%MSP}$ used for US management (NEFSC 2002).

### Stock and Recruitment

There is evidence of reduced recruitment at low levels of spawning stock biomass (Fig. 31). Based on the spawning stock biomass and recruitment relationship observed in a previous stock assessment, the $B_{MSY}$ level of 58,800 mt of spawning stock biomass was set as the rebuilding goal in the US for this stock (NEFSC 2002). Current levels of SSB are considerably lower than the rebuilding goal (9%).

## OUTLOOK

Yield was projected deterministically using 2006 beginning of year population abundance estimates, assuming a 2006 catch equal to the 3,000 mt quota. Recruitment in 2006-2008 was set equal to 17.1 million age-1 fish (geometric mean of the previous ten years), and fishery partial recruitment was estimated as the average of the previous three years. Projected total Canada/US yield at $F_{ref} = 0.25$ in 2007 would be 1,173 mt (Table 15). If fished at $F_{ref}$ in 2007, the adult biomass (ages 3+) is projected to increase from 5,221 mt in 2007 to 8,911 mt at the beginning of 2008. The 2006 quota of 3,000 mt causes projected fully recruited F to be above $F_{ref}$ in 2006 ($F_{2006}=0.83$).

The outlook is provided in terms of the possible consequences for alternative catch quotas in 2007 with respect to the harvest reference points. Uncertainty about stock size generates uncertainty in forecast results. This uncertainty is expressed in the outlook as the risk of exceeding $F_{ref} = 0.25$. The risk calculations provide a general sense of the uncertainties and assist with evaluating the consequences of alternative catch quotas. These calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting or the possibility that the model may not reflect the stock dynamics closely enough. Also, the risk calculations are dependent on the model assumptions and data used in the analyses.

A combined Canada/US yield of about 1,250 mt in 2007 has a neutral risk, about 50%, of exceeding $F_{ref}$ according to the Major Change VPA (Fig. 32). Fishing at this rate in 2007 causes the median age 3+ biomass to increase from 5,574 mt in 2007 to 9,236 mt in 2008 (66% increase). Since the US software was used for this assessment, and it is not currently configured to make bias corrections, the above probability statement is overly optimistic relative to the bias corrected probability statement, however, the bias is small (Table 10). The uncertainty imposed by the unexplained changes in survey catchability is large and means that the risks associated with given catch levels are underestimated, so caution should be used when basing management decisions on these results.

Due to the truncated age structure, medium term projections are highly dependent on future recruitment and therefore were not conducted.

Age structure, fish condition, and spatial distribution reflect stock productivity. The current age structure indicates that very little rebuilding of ages 5 and older has occurred and that the population is still dominated by younger ages 1 through 4 (Fig. 33). Far fewer older fish (6+) are estimated in the VPA in comparison with the population at equilibrium, which is inconsistent with the perception of recent low exploitation. The spatial distribution patterns from the NMFS surveys suggest a concentration in stratum 16, while the inability of Canadian fishermen to find commercial concentrations of yellowtail the past two years suggests a westward shift in distribution. Truncated age structure in the surveys and change in distribution indicate current productivity may be limited relative to historical levels.

## MANAGEMENT CONSIDERATIONS

This assessment is hampered by inconsistencies between the age structure of the catch and the age-specific indices of abundance. Although the catch of old fish has increased in recent years, it is still less than would be expected given the increases seen in the age-specific indices of abundance. The noisy character of the indices cause difficulty in tuning age structured models.

Consistent management by Canada and the US is required to ensure that conservation objectives are not compromised.

Both VPA formulations have difficulties with interpretation (see benchmark report for full details; TRAC 2005). The Base Case VPA has a strong pattern in residuals and a strong

retrospective pattern. The Major Change VPA adds parameters to decrease these patterns in residuals and the retrospective, but the mechanism for the changes in survey catchability are not easily explained. These changes in survey catchability are most appropriately thought of as an aliasing of an unknown mechanism that produces a better fitting model. However, the closer match of the Major Change VPA to the recent downward trends seen in all three surveys made it the choice for management decisions at the TRAC meeting (O'Boyle and Overholtz, 2006).

Catching the TAC of 3,000 mt in 2006 will result in a fishing mortality rate above $F_{ref} = 0.25$ ($F_{2006}$=0.83).

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**Table 1**. Annual catch (000s mt) of Georges Bank yellowtail flounder.

| Year | US landings | US discards | Canadian landings | Canadian discards | Foreign Catch | Total Catch |
|---|---|---|---|---|---|---|
| 1963 | 10.990 | 5.600 | - | - | 0.100 | 16.690 |
| 1964 | 14.914 | 4.900 | - | - | 0.000 | 19.814 |
| 1965 | 14.248 | 4.400 | - | - | 0.800 | 19.448 |
| 1966 | 11.341 | 2.100 | - | - | 0.300 | 13.741 |
| 1967 | 8.407 | 5.500 | - | - | 1.400 | 15.307 |
| 1968 | 12.799 | 3.600 | 0.122 | - | 1.800 | 18.321 |
| 1969 | 15.944 | 2.600 | 0.327 | - | 2.400 | 21.271 |
| 1970 | 15.506 | 5.533 | 0.071 | - | 0.250 | 21.410 |
| 1971 | 11.878 | 3.127 | 0.105 | - | 0.503 | 15.610 |
| 1972 | 14.157 | 1.159 | 0.008 | 0.515 | 2.243 | 18.039 |
| 1973 | 15.899 | 0.364 | 0.012 | 0.378 | 0.260 | 16.953 |
| 1974 | 14.607 | 0.980 | 0.005 | 0.619 | 1.000 | 17.211 |
| 1975 | 13.205 | 2.715 | 0.008 | 0.722 | 0.091 | 16.750 |
| 1976 | 11.336 | 3.021 | 0.012 | 0.619 | 0.000 | 14.988 |
| 1977 | 9.444 | 0.567 | 0.044 | 0.584 | 0.000 | 10.639 |
| 1978 | 4.519 | 1.669 | 0.069 | 0.687 | 0.000 | 6.944 |
| 1979 | 5.475 | 0.720 | 0.019 | 0.722 | 0.000 | 6.935 |
| 1980 | 6.481 | 0.382 | 0.092 | 0.584 | 0.000 | 7.539 |
| 1981 | 6.182 | 0.095 | 0.015 | 0.687 | 0.000 | 6.979 |
| 1982 | 10.621 | 1.376 | 0.022 | 0.502 | 0.000 | 12.520 |
| 1983 | 11.350 | 0.072 | 0.106 | 0.460 | 0.000 | 11.989 |
| 1984 | 5.763 | 0.028 | 0.008 | 0.481 | 0.000 | 6.280 |
| 1985 | 2.477 | 0.043 | 0.025 | 0.722 | 0.000 | 3.267 |
| 1986 | 3.041 | 0.019 | 0.057 | 0.357 | 0.000 | 3.474 |
| 1987 | 2.742 | 0.233 | 0.069 | 0.536 | 0.000 | 3.580 |
| 1988 | 1.866 | 0.252 | 0.056 | 0.584 | 0.000 | 2.759 |
| 1989 | 1.134 | 0.073 | 0.040 | 0.536 | 0.000 | 1.783 |
| 1990 | 2.751 | 0.818 | 0.025 | 0.495 | 0.000 | 4.089 |
| 1991 | 1.784 | 0.246 | 0.081 | 0.454 | 0.000 | 2.564 |
| 1992 | 2.859 | 1.873 | 0.065 | 0.502 | 0.000 | 5.299 |
| 1993 | 2.089 | 1.089 | 0.682 | 0.440 | 0.000 | 4.300 |
| 1994 | 1.589 | 0.158 | 2.139 | 0.440 | 0.000 | 4.326 |
| 1995 | 0.292 | 0.038 | 0.464 | 0.268 | 0.000 | 1.183 |
| 1996 | 0.751 | 0.071 | 0.472 | 0.388 | 0.000 | 1.682 |
| 1997 | 0.966 | 0.058 | 0.810 | 0.438 | 0.000 | 2.272 |
| 1998 | 1.822 | 0.116 | 1.175 | 0.708 | 0.000 | 3.821 |
| 1999 | 1.987 | 0.484 | 1.971 | 0.597 | 0.000 | 5.038 |
| 2000 | 3.678 | 0.408 | 2.859 | 0.415 | 0.000 | 7.360 |
| 2001 | 3.792 | 0.337 | 2.913 | 0.815 | 0.000 | 7.857 |
| 2002 | 2.532 | 0.248 | 2.642 | 0.493 | 0.000 | 5.915 |
| 2003 | 3.343 | 0.373 | 2.107 | 0.809 | 0.000 | 6.632 |
| 2004 | 6.208 | 0.548 | 0.096 | 0.422 | 0.000 | 7.275 |
| 2005 | 3.327 | 0.476 | 0.030 | 0.317 | 0.000 | 4.150 |

**Table 2**. Port samples used in the estimation of landings at age for Georges Bank yellowtail flounder in 2005 from Canadian and US sources.

| **USA** | **Port Samples** | | | | *Sea Samples* | | | **Landings** |
|---|---|---|---|---|---|---|---|---|
| Quarter | Size | Trips | Lengths | Ages | Trips | Lengths | Ages | (mt) |
| 1 | All | 20 | 1,819 | 399 | 130 | 11,341 | 0 | 596 |
| 2 | All | 18 | 1,814 | 365 | 203 | 18,084 | 0 | 869 |
| 3 | All | 17 | 1,617 | 337 | 108 | 9,181 | 0 | 973 |
| 4 | All | 26 | 3,045 | 697 | 123 | 19,466 | 0 | 889 |
| All | All | 81 | 8,295 | 1,798 | 564 | 58,072 | 0 | 3,327 |
| **Canada** | **Port Samples** | | | | **Sea Samples** | | | **Landings** |
| Quarter | Size | Trips | Lengths | Ages | Trips | Lengths | Ages | (mt) |
| 1 | | 0 | | | 0 | | | 0 |
| 2 | | 0 | | | 0 | | | 22 |
| 3 | All | 3 | 394 | 0 | 1 | 280 | 0 | 4 |
| 4 | | 0 | | | 0 | | | 4 |
| All | All | 3 | 394 | 0 | 1 | 280 | 0 | 30 |

**Table 3**. Total catch at age including discards (number in 000's) for Georges Bank yellowtail flounder, 1973-2005.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | **Total** |
| 1973 | 359 | 5175 | 13565 | 9473 | 3815 | 1285 | 283 | 55 | 23 | 4 | 0 | 0 | 34037 |
| 1974 | 2368 | 9500 | 8294 | 7658 | 3643 | 878 | 464 | 106 | 71 | 0 | 0 | 0 | 32982 |
| 1975 | 4636 | 26394 | 7375 | 3540 | 2175 | 708 | 327 | 132 | 26 | 14 | 0 | 0 | 45328 |
| 1976 | 635 | 31938 | 5502 | 1426 | 574 | 453 | 304 | 95 | 54 | 11 | 2 | 0 | 40993 |
| 1977 | 378 | 9094 | 10567 | 1846 | 419 | 231 | 134 | 82 | 37 | 10 | 0 | 0 | 22799 |
| 1978 | 9962 | 3542 | 4580 | 1914 | 540 | 120 | 45 | 16 | 17 | 7 | 6 | 0 | 20748 |
| 1979 | 321 | 10517 | 3789 | 1432 | 623 | 167 | 95 | 31 | 27 | 1 | 3 | 0 | 17006 |
| 1980 | 318 | 3994 | 9685 | 1538 | 352 | 96 | 5 | 11 | 1 | 0 | 0 | 0 | 16000 |
| 1981 | 107 | 1097 | 5963 | 4920 | 854 | 135 | 5 | 2 | 3 | 0 | 0 | 0 | 13088 |
| 1982 | 2164 | 18091 | 7480 | 3401 | 1095 | 68 | 20 | 7 | 0 | 0 | 0 | 0 | 32327 |
| 1983 | 703 | 7998 | 16661 | 2476 | 680 | 122 | 13 | 16 | 4 | 0 | 0 | 0 | 28672 |
| 1984 | 514 | 2018 | 4535 | 5043 | 1796 | 294 | 47 | 39 | 0 | 0 | 0 | 0 | 14285 |
| 1985 | 970 | 4374 | 1058 | 818 | 517 | 73 | 8 | 0 | 0 | 0 | 0 | 0 | 7817 |
| 1986 | 179 | 6402 | 1127 | 389 | 204 | 80 | 17 | 15 | 0 | 1 | 0 | 0 | 8414 |
| 1987 | 156 | 3284 | 3137 | 983 | 192 | 48 | 38 | 26 | 25 | 0 | 0 | 0 | 7890 |
| 1988 | 499 | 3003 | 1544 | 846 | 227 | 24 | 26 | 3 | 0 | 0 | 0 | 0 | 6172 |
| 1989 | 190 | 2175 | 1121 | 428 | 110 | 18 | 12 | 0 | 0 | 0 | 0 | 0 | 4054 |
| 1990 | 231 | 2114 | 6996 | 978 | 140 | 21 | 6 | 0 | 0 | 0 | 0 | 0 | 10485 |
| 1991 | 663 | 147 | 1491 | 3011 | 383 | 67 | 4 | 0 | 0 | 0 | 0 | 0 | 5767 |
| 1992 | 2414 | 9167 | 2971 | 1473 | 603 | 33 | 7 | 1 | 1 | 0 | 0 | 0 | 16671 |
| 1993 | 5233 | 1386 | 3327 | 2326 | 411 | 84 | 5 | 1 | 0 | 0 | 0 | 0 | 12773 |
| 1994 | 59 | 1432 | 6631 | 1856 | 568 | 95 | 23 | 1 | 0 | 0 | 0 | 0 | 10666 |
| 1995 | 62 | 233 | 1428 | 986 | 211 | 17 | 23 | 4 | 2 | 0 | 0 | 0 | 2967 |
| 1996 | 54 | 566 | 1922 | 941 | 234 | 11 | 9 | 3 | 0 | 0 | 0 | 0 | 3740 |
| 1997 | 60 | 745 | 1502 | 1827 | 442 | 36 | 55 | 11 | 5 | 0 | 0 | 0 | 4683 |
| 1998 | 64 | 1496 | 3224 | 2134 | 782 | 143 | 26 | 3 | 0 | 2 | 0 | 0 | 7872 |
| 1999 | 37 | 3694 | 3583 | 1731 | 743 | 180 | 34 | 1 | 1 | 0 | 0 | 0 | 10003 |
| 2000 | 155 | 3840 | 5985 | 3120 | 832 | 340 | 43 | 36 | 1 | 0 | 0 | 0 | 14352 |
| 2001 | 284 | 3065 | 7622 | 2824 | 1093 | 293 | 254 | 23 | 9 | 0 | 0 | 0 | 15468 |
| 2002 | 256 | 4437 | 3854 | 1845 | 670 | 263 | 113 | 62 | 11 | 5 | 0 | 0 | 11517 |
| 2003 | 160 | 3818 | 4965 | 2297 | 777 | 328 | 213 | 93 | 39 | 15 | 1 | 0 | 12708 |
| 2004 | 78 | 1336 | 3491 | 4093 | 2088 | 919 | 429 | 85 | 73 | 20 | 2 | 0 | 12613 |
| 2005 | 54 | 1657 | 4362 | 1836 | 424 | 144 | 39 | 18 | 0 | 0 | 0 | 0 | 8535 |

**Table 4**. Mean weight at age (kg) for the total catch including US and Canadian discards, for Georges Bank yellowtail flounder, 1973-2005.

| | Age | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1973 | 0.101 | 0.348 | 0.462 | 0.527 | 0.603 | 0.690 | 1.063 | 1.131 | 1.275 | 1.389 | 1.170 | |
| 1974 | 0.115 | 0.344 | 0.496 | 0.607 | 0.678 | 0.723 | 0.904 | 1.245 | 1.090 | | 1.496 | 1.496 |
| 1975 | 0.113 | 0.316 | 0.489 | 0.554 | 0.619 | 0.690 | 0.691 | 0.654 | 1.052 | 0.812 | | |
| 1976 | 0.108 | 0.312 | 0.544 | 0.635 | 0.744 | 0.813 | 0.854 | 0.881 | 1.132 | 1.363 | 1.923 | |
| 1977 | 0.116 | 0.342 | 0.524 | 0.633 | 0.780 | 0.860 | 1.026 | 1.008 | 0.866 | 0.913 | | |
| 1978 | 0.102 | 0.314 | 0.510 | 0.690 | 0.803 | 0.903 | 0.947 | 1.008 | 1.227 | 1.581 | 0.916 | |
| 1979 | 0.114 | 0.329 | 0.462 | 0.656 | 0.736 | 0.844 | 0.995 | 0.906 | 1.357 | 1.734 | 1.911 | |
| 1980 | 0.101 | 0.322 | 0.493 | 0.656 | 0.816 | 1.048 | 1.208 | 1.206 | 1.239 | | | |
| 1981 | 0.122 | 0.335 | 0.489 | 0.604 | 0.707 | 0.821 | 0.844 | 1.599 | 1.104 | | | |
| 1982 | 0.115 | 0.301 | 0.485 | 0.650 | 0.754 | 1.065 | 1.037 | 1.361 | | | | |
| 1983 | 0.140 | 0.296 | 0.441 | 0.607 | 0.740 | 0.964 | 1.005 | 1.304 | 1.239 | | | |
| 1984 | 0.162 | 0.239 | 0.379 | 0.500 | 0.647 | 0.743 | 0.944 | 1.032 | | | | |
| 1985 | 0.181 | 0.361 | 0.505 | 0.642 | 0.729 | 0.808 | 0.728 | | | | | |
| 1986 | 0.181 | 0.341 | 0.540 | 0.674 | 0.854 | 0.976 | 0.950 | 1.250 | | 1.686 | | |
| 1987 | 0.121 | 0.324 | 0.524 | 0.680 | 0.784 | 0.993 | 0.838 | 0.771 | 0.809 | | | |
| 1988 | 0.103 | 0.328 | 0.557 | 0.696 | 0.844 | 1.042 | 0.865 | 1.385 | | | | |
| 1989 | 0.100 | 0.327 | 0.520 | 0.720 | 0.866 | 0.970 | 1.172 | 1.128 | | | | |
| 1990 | 0.105 | 0.290 | 0.395 | 0.585 | 0.693 | 0.787 | 1.057 | | | | | |
| 1991 | 0.121 | 0.237 | 0.369 | 0.486 | 0.723 | 0.850 | 1.306 | | | | | |
| 1992 | 0.101 | 0.293 | 0.365 | 0.526 | 0.651 | 1.098 | 1.125 | 1.303 | 1.303 | | | |
| 1993 | 0.100 | 0.285 | 0.379 | 0.501 | 0.564 | 0.843 | 1.130 | 1.044 | | | | |
| 1994 | 0.195 | 0.255 | 0.348 | 0.469 | 0.620 | 0.810 | 0.723 | 1.257 | | | | |
| 1995 | 0.167 | 0.246 | 0.352 | 0.463 | 0.584 | 0.766 | 0.805 | 0.532 | 0.810 | | | |
| 1996 | 0.140 | 0.292 | 0.412 | 0.563 | 0.721 | 0.916 | 1.062 | 1.287 | | | | |
| 1997 | 0.206 | 0.319 | 0.421 | 0.537 | 0.690 | 0.837 | 0.878 | 1.184 | 1.126 | | | |
| 1998 | 0.184 | 0.325 | 0.447 | 0.543 | 0.690 | 0.903 | 0.932 | 1.195 | | 1.473 | | |
| 1999 | 0.190 | 0.369 | 0.503 | 0.638 | 0.756 | 0.900 | 1.030 | 1.496 | 1.822 | | | |
| 2000 | 0.220 | 0.379 | 0.481 | 0.613 | 0.762 | 0.915 | 1.020 | 0.996 | 1.229 | | | |
| 2001 | 0.225 | 0.343 | 0.456 | 0.624 | 0.808 | 1.013 | 1.023 | 1.272 | 1.483 | | | |
| 2002 | 0.263 | 0.382 | 0.489 | 0.668 | 0.829 | 0.983 | 1.062 | 1.282 | 1.389 | 1.433 | | |
| 2003 | 0.226 | 0.360 | 0.477 | 0.652 | 0.830 | 0.945 | 1.033 | 1.148 | 1.273 | 1.432 | 1.708 | |
| 2004 | 0.194 | 0.292 | 0.436 | 0.581 | 0.723 | 0.884 | 1.001 | 1.206 | 1.207 | 1.306 | 1.421 | |
| 2005 | 0.129 | 0.345 | 0.447 | 0.599 | 0.763 | 0.965 | 0.984 | 1.221 | 1.573 | 1.573 | | |

**Table 5**. Canadian DFO spring survey indices of Georges Bank yellowtail flounder abundance at age (stratified mean #/tow) and stratified total biomass (000s mt).

| | Age | | | | | | | | | | | | | Biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total | (000 mt) |
| 1987 | 0.12 | 0.99 | 2.00 | 0.64 | 0.12 | 0.00 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 3.91 | 1.26 |
| 1988 | 0.00 | 1.59 | 1.29 | 0.76 | 0.30 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.96 | 1.24 |
| 1989 | 0.11 | 0.94 | 0.58 | 0.36 | 0.09 | 0.01 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 2.13 | 0.47 |
| 1990 | 0.00 | 2.36 | 3.38 | 1.06 | 0.32 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.15 | 1.58 |
| 1991 | 0.02 | 0.86 | 1.53 | 3.23 | 0.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.37 | 1.76 |
| 1992 | 0.06 | 10.74 | 3.97 | 1.03 | 0.30 | 0.01 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 16.14 | 2.48 |
| 1993 | 0.08 | 2.24 | 3.26 | 4.41 | 1.64 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.69 | 2.64 |
| 1994 | 0.00 | 6.06 | 3.46 | 3.01 | 0.78 | 0.13 | 0.03 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 13.51 | 2.75 |
| 1995 | 0.21 | 1.19 | 4.28 | 2.55 | 0.79 | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.11 | 2.03 |
| 1996 | 0.45 | 6.65 | 8.58 | 6.61 | 1.01 | 0.09 | 0.02 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 23.45 | 5.30 |
| 1997 | 0.02 | 9.78 | 14.67 | 17.96 | 4.32 | 0.53 | 0.11 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 47.49 | 13.29 |
| 1998 | 0.89 | 3.18 | 4.89 | 4.50 | 2.02 | 0.46 | 0.03 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 16.01 | 4.29 |
| 1999 | 0.16 | 11.84 | 27.24 | 7.95 | 7.30 | 2.21 | 0.34 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 57.07 | 17.67 |
| 2000 | 0.01 | 9.47 | 32.90 | 17.80 | 5.54 | 2.96 | 0.32 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 69.22 | 19.95 |
| 2001 | 0.29 | 15.18 | 47.13 | 13.35 | 3.70 | 1.95 | 0.90 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 82.60 | 22.16 |
| 2002 | 0.09 | 9.67 | 33.73 | 11.27 | 5.97 | 1.54 | 0.95 | 0.38 | 0.08 | 0.00 | 0.00 | 0.00 | 63.68 | 20.62 |
| 2003 | 0.07 | 6.76 | 27.36 | 13.45 | 3.57 | 0.86 | 0.62 | 0.25 | 0.12 | 0.04 | 0.00 | 0.00 | 53.09 | 16.25 |
| 2004 | 0.03 | 3.60 | 16.26 | 9.21 | 2.27 | 0.63 | 0.23 | 0.46 | 0.09 | 0.00 | 0.00 | 0.00 | 32.79 | 14.01 |
| 2005 | 0.60 | 1.60 | 27.96 | 20.56 | 5.70 | 1.04 | 0.40 | 0.10 | 0.01 | 0.01 | 0.00 | 0.00 | 57.99 | 13.36 |
| 2006 | 0.00 | 4.89 | 18.60 | 6.57 | 0.82 | 0.16 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.12 | 10.46 |

**Table 6**. NMFS spring survey indices (stratified mean #/tow) of Georges Bank yellowtail flounder abundance at age and total biomass (stratified mean kg/tow).

| | Age | | | | | | | | | | | | | Biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total | kg/tow |
| 1968 | 0.15 | 3.36 | 3.58 | 0.32 | 0.08 | 0.16 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.78 | 2.81 |
| 1969 | 1.02 | 9.41 | 11.12 | 3.10 | 1.42 | 0.45 | 0.19 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 26.76 | 11.17 |
| 1970 | 0.09 | 4.49 | 6.03 | 2.42 | 0.57 | 0.12 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 13.91 | 5.31 |
| 1971 | 0.79 | 3.34 | 4.62 | 3.75 | 0.76 | 0.23 | 0.05 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 13.56 | 4.61 |
| 1972 | 0.14 | 7.14 | 7.20 | 3.51 | 1.09 | 0.05 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19.25 | 6.45 |
| 1973 | 1.93 | 3.27 | 2.37 | 1.06 | 0.41 | 0.17 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 9.25 | 2.94 |
| 1974 | 0.32 | 2.22 | 1.84 | 1.26 | 0.35 | 0.19 | 0.09 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 6.27 | 2.72 |
| 1975 | 0.42 | 2.94 | 0.86 | 0.30 | 0.21 | 0.07 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 4.81 | 1.68 |
| 1976 | 1.03 | 4.37 | 1.25 | 0.31 | 0.20 | 0.03 | 0.05 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 7.27 | 2.27 |
| 1977 | 0.00 | 0.67 | 1.13 | 0.38 | 0.07 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.27 | 1.00 |
| 1978 | 0.94 | 0.80 | 0.51 | 0.22 | 0.03 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.49 | 0.74 |
| 1979 | 0.28 | 1.93 | 0.39 | 0.33 | 0.06 | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.07 | 1.23 |
| 1980 | 0.06 | 4.64 | 5.76 | 0.47 | 0.06 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.03 | 4.46 |
| 1981 | 0.01 | 1.03 | 1.78 | 0.72 | 0.21 | 0.06 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 3.83 | 1.96 |
| 1982 | 0.05 | 3.74 | 1.12 | 1.02 | 0.46 | 0.07 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 6.47 | 2.50 |
| 1983 | 0.00 | 1.87 | 2.73 | 0.53 | 0.12 | 0.09 | 0.06 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 5.49 | 2.64 |
| 1984 | 0.00 | 0.09 | 0.81 | 0.89 | 0.83 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.87 | 1.65 |
| 1985 | 0.11 | 2.20 | 0.26 | 0.28 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.00 | 0.99 |
| 1986 | 0.03 | 1.81 | 0.29 | 0.06 | 0.14 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.37 | 0.85 |
| 1987 | 0.00 | 0.13 | 0.11 | 0.13 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.48 | 0.33 |
| 1988 | 0.08 | 0.28 | 0.37 | 0.24 | 0.20 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.19 | 0.57 |
| 1989 | 0.05 | 0.42 | 0.74 | 0.29 | 0.06 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.61 | 0.73 |
| 1990 | 0.00 | 0.06 | 1.11 | 0.39 | 0.14 | 0.01 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.76 | 0.70 |
| 1991 | 0.44 | 0.00 | 0.25 | 0.68 | 0.27 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.66 | 0.63 |
| 1992 | 0.00 | 2.01 | 1.95 | 0.60 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.74 | 1.57 |
| 1993 | 0.05 | 0.29 | 0.50 | 0.32 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.18 | 0.48 |
| 1994 | 0.00 | 0.62 | 0.64 | 0.36 | 0.15 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.80 | 0.66 |
| 1995 | 0.04 | 1.18 | 4.81 | 1.49 | 0.64 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.17 | 2.58 |
| 1996 | 0.03 | 0.99 | 2.63 | 2.70 | 0.61 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.02 | 2.85 |
| 1997 | 0.02 | 1.17 | 3.73 | 4.08 | 0.70 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.84 | 4.36 |
| 1998 | 0.00 | 2.08 | 1.05 | 1.16 | 0.76 | 0.32 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.40 | 2.32 |
| 1999 | 0.05 | 4.75 | 10.82 | 2.72 | 1.62 | 0.43 | 0.33 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 20.74 | 9.31 |
| 2000 | 0.18 | 4.82 | 7.67 | 2.91 | 0.81 | 0.42 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.92 | 6.70 |
| 2001 | 0.00 | 2.31 | 6.56 | 2.41 | 0.48 | 0.35 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.23 | 5.01 |
| 2002 | 0.19 | 2.41 | 12.33 | 4.08 | 1.74 | 0.38 | 0.41 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 21.62 | 9.57 |
| 2003 | 0.20 | 4.37 | 6.76 | 2.88 | 0.44 | 0.13 | 0.54 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 15.52 | 6.72 |
| 2004 | 0.05 | 0.99 | 2.18 | 0.68 | 0.28 | 0.11 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 4.42 | 1.89 |
| 2005 | 0.00 | 2.01 | 5.08 | 2.40 | 0.27 | 0.04 | 0.05 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 9.88 | 3.40 |
| 2006 | 0.51 | 0.94 | 3.52 | 2.18 | 0.32 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.54 | 2.42 |

**Table 7**. NMFS fall survey indices (stratified mean #/tow) of Georges Bank yellowtail flounder abundance at age and total biomass (stratified mean kg/tow).

| | Age | | | | | | | | | | | | | | | Biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total | (kg/tow) |
| 1963 | 14.72 | 7.90 | 11.23 | 1.86 | 0.50 | 0.28 | 0.03 | 0.16 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 36.75 | 12.79 |
| 1964 | 1.72 | 9.72 | 7.37 | 6.00 | 2.69 | 0.38 | 0.09 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.01 | 13.63 |
| 1965 | 1.14 | 5.58 | 5.47 | 3.86 | 1.80 | 0.16 | 0.28 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.33 | 9.10 |
| 1966 | 8.77 | 4.78 | 2.07 | 0.84 | 0.09 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.60 | 3.99 |
| 1967 | 9.14 | 9.31 | 2.70 | 1.01 | 0.31 | 0.08 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 22.60 | 7.58 |
| 1968 | 11.78 | 11.95 | 5.76 | 0.77 | 0.94 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.25 | 10.53 |
| 1969 | 8.11 | 10.38 | 5.86 | 1.66 | 0.55 | 0.15 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 26.89 | 9.28 |
| 1970 | 4.61 | 5.13 | 3.14 | 1.95 | 0.45 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 15.37 | 4.98 |
| 1971 | 3.63 | 6.95 | 4.90 | 2.25 | 0.55 | 0.23 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.56 | 6.36 |
| 1972 | 2.42 | 6.53 | 4.82 | 2.10 | 0.67 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 16.82 | 6.33 |
| 1973 | 2.49 | 5.50 | 5.10 | 2.94 | 1.22 | 0.42 | 0.17 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 17.87 | 6.60 |
| 1974 | 4.62 | 2.85 | 1.52 | 1.06 | 0.46 | 0.25 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.90 | 3.73 |
| 1975 | 4.63 | 2.51 | 0.88 | 0.57 | 0.33 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 8.98 | 2.36 |
| 1976 | 0.34 | 1.93 | 0.48 | 0.12 | 0.12 | 0.03 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.08 | 1.53 |
| 1977 | 0.93 | 2.16 | 1.65 | 0.62 | 0.11 | 0.06 | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.58 | 2.83 |
| 1978 | 4.73 | 1.27 | 0.77 | 0.41 | 0.14 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.35 | 2.38 |
| 1979 | 1.31 | 2.00 | 0.32 | 0.12 | 0.14 | 0.04 | 0.06 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.00 | 1.52 |
| 1980 | 0.76 | 5.09 | 6.05 | 0.68 | 0.22 | 0.16 | 0.01 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.99 | 6.72 |
| 1981 | 1.58 | 2.33 | 1.63 | 0.50 | 0.12 | 0.08 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.26 | 2.62 |
| 1982 | 2.42 | 2.19 | 1.59 | 0.42 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.71 | 2.27 |
| 1983 | 0.11 | 2.28 | 1.91 | 0.47 | 0.07 | 0.01 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.90 | 2.13 |
| 1984 | 0.66 | 0.40 | 0.31 | 2.43 | 0.09 | 0.03 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.93 | 0.59 |
| 1985 | 1.35 | 0.56 | 0.16 | 0.04 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.19 | 0.71 |
| 1986 | 0.28 | 1.11 | 0.35 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.81 | 0.82 |
| 1987 | 0.11 | 0.39 | 0.40 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.03 | 0.51 |
| 1988 | 0.02 | 0.21 | 0.10 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.37 | 0.17 |
| 1989 | 0.25 | 1.99 | 0.77 | 0.07 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.15 | 0.98 |
| 1990 | 0.00 | 0.33 | 1.52 | 0.28 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.14 | 0.72 |
| 1991 | 2.10 | 0.28 | 0.44 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.17 | 0.73 |
| 1992 | 0.15 | 0.40 | 0.71 | 0.16 | 0.14 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.59 | 0.58 |
| 1993 | 0.84 | 0.14 | 0.59 | 0.54 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.10 | 0.55 |
| 1994 | 1.20 | 0.22 | 0.98 | 0.71 | 0.26 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.43 | 0.90 |
| 1995 | 0.28 | 0.12 | 0.35 | 0.28 | 0.05 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.09 | 0.35 |
| 1996 | 0.14 | 0.35 | 1.87 | 0.45 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.88 | 1.30 |
| 1997 | 1.39 | 0.53 | 3.44 | 2.09 | 1.07 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.61 | 3.78 |
| 1998 | 1.90 | 4.82 | 4.20 | 1.19 | 0.30 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.48 | 4.35 |
| 1999 | 3.09 | 8.42 | 5.73 | 1.43 | 1.44 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 20.37 | 7.97 |
| 2000 | 0.63 | 1.70 | 4.81 | 2.42 | 0.95 | 0.80 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.34 | 5.84 |
| 2001 | 3.52 | 6.27 | 8.09 | 2.60 | 1.72 | 0.71 | 1.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.24 | 11.55 |
| 2002 | 2.09 | 5.75 | 2.13 | 0.59 | 0.28 | 0.00 | 0.03 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.90 | 3.76 |
| 2003 | 1.10 | 5.01 | 2.81 | 0.56 | 0.10 | 0.09 | 0.07 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 9.77 | 4.04 |
| 2004 | 0.88 | 5.51 | 5.01 | 2.11 | 0.92 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.60 | 5.12 |
| 2005 | 0.31 | 2.10 | 3.76 | 0.57 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.97 | 2.46 |

**Table 8**. NMFS scallop survey index (stratified mean #/tow) for Georges Bank yellowtail flounder age-1 abundance.

| Year | Number per tow |
|---|---|
| 1982 | 0.313 |
| 1983 | 0.140 |
| 1984 | 0.233 |
| 1985 | 0.549 |
| 1986 | 0.103 |
| 1987 | 0.047 |
| 1988 | 0.116 |
| 1989 | 0.195 |
| 1990 | 0.100 |
| 1991 | 2.117 |
| 1992 | 0.167 |
| 1993 | 1.129 |
| 1994 | 1.503 |
| 1995 | 0.609 |
| 1996 | 0.508 |
| 1997 | 1.062 |
| 1998 | 1.872 |
| 1999 | 1.038 |
| 2000 | 0.912 |
| 2001 | 0.789 |
| 2002 | 1.005 |
| 2003 | 0.880 |
| 2004 | 0.330 |
| 2005 | 0.573 |

**Table 9**. Statistical properties of estimates for population abundance (000s) and survey calibration constants ($x10^3$) for Georges Bank yellowtail flounder for the Base Case VPA using US ADAPT software.

| | | Bootstrap | | | | |
|---|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias | Bias/SE |
| | **Population Abundance** | | | | | |
| 2 | 11865 | 6465 | 54.5% | 1180 | 9.9% | 18% |
| 3 | 11423 | 4395 | 38.5% | 819 | 7.2% | 19% |
| 4 | 10468 | 3670 | 35.1% | 647 | 6.2% | 18% |
| 5 | 2146 | 663 | 30.9% | 83 | 3.9% | 13% |
| | **Survey Calibration Constants** | | | | | |
| *DFO Survey: 1987-2006 (Ages 2-6+)* | | | | | | |
| 2 | 0.295 | 0.057 | 19.4% | 0.009 | 3.0% | 16% |
| 3 | 0.942 | 0.195 | 20.7% | 0.021 | 2.2% | 11% |
| 4 | 1.345 | 0.232 | 17.3% | 0.017 | 1.3% | 7% |
| 5 | 1.456 | 0.296 | 20.3% | 0.034 | 2.3% | 11% |
| 6+ | 1.164 | 0.263 | 22.6% | 0.026 | 2.2% | 10% |
| *NMFS Spring Survey: Yankee 41, 1973-1981 (Ages 1-6+)* | | | | | | |
| 1 | 0.007 | 0.006 | 82.6% | 0.001 | 19.4% | 23% |
| 2 | 0.077 | 0.014 | 18.5% | 0.001 | 1.7% | 9% |
| 3 | 0.098 | 0.018 | 18.0% | 0.002 | 1.6% | 9% |
| 4 | 0.096 | 0.012 | 12.1% | 0.001 | 1.2% | 10% |
| 5 | 0.076 | 0.015 | 19.6% | 0.000 | 0.3% | 2% |
| 6+ | 0.076 | 0.028 | 36.8% | 0.005 | 6.0% | 16% |
| *NMFS Spring Survey: Yankee 36, 1982-2006 (Ages 1-6+)* | | | | | | |
| 1 | 0.004 | 0.001 | 19.9% | 0.000 | 0.9% | 4% |
| 2 | 0.080 | 0.015 | 18.7% | 0.001 | 1.0% | 5% |
| 3 | 0.204 | 0.041 | 20.2% | 0.001 | 0.6% | 3% |
| 4 | 0.274 | 0.047 | 17.1% | 0.007 | 2.4% | 14% |
| 5 | 0.323 | 0.058 | 17.8% | 0.009 | 2.9% | 16% |
| 6+ | 0.436 | 0.074 | 17.0% | 0.007 | 1.7% | 10% |
| *NMFS Fall Survey: 1973-2005 (Ages 1-6+)* | | | | | | |
| 1 | 0.045 | 0.008 | 18.8% | 0.001 | 2.0% | 11% |
| 2 | 0.109 | 0.018 | 16.6% | 0.001 | 1.0% | 6% |
| 3 | 0.219 | 0.027 | 12.5% | 0.001 | 0.6% | 5% |
| 4 | 0.226 | 0.031 | 13.9% | 0.001 | 0.3% | 2% |
| 5 | 0.286 | 0.047 | 16.3% | 0.001 | 0.5% | 3% |
| 6+ | 0.350 | 0.074 | 21.2% | 0.006 | 1.8% | 8% |
| *NMFS Scallop Survey: 1982-2005 (Age 1)* | | | | | | |
| 1 | 0.032 | 0.006 | 18.9% | 0.001 | 1.6% | 9% |

**Table 10**. Statistical properties of estimates for population abundance (000s) and survey calibration constants ($x10^3$) for Georges Bank yellowtail flounder for the Major Change VPA using US ADAPT software. (Table continues on next page)

| | | Bootstrap | | | | |
|---|---|---|---|---|---|---|
| Age | Estimate | Standard Error | Relative Error | Bias | Relative Bias | Bias/SE |
| **Population Abundance** | | | | | | |
| 2 | 7478 | 2375 | 31.8% | 346 | 4.6% | 15% |
| 3 | 6412 | 2019 | 31.5% | 256 | 4.0% | 13% |
| 4 | 4418 | 1493 | 33.8% | 229 | 5.2% | 15% |
| 5 | 552 | 198 | 35.9% | 34 | 6.2% | 17% |
| **Survey Calibration Constants** | | | | | | |
| *DFO Survey: 1987-1994 (Ages 2-6+)* | | | | | | |
| 2 | 0.213 | 0.069 | 32.6% | 0.010 | 4.8% | 15% |
| 3 | 0.365 | 0.049 | 13.3% | 0.003 | 0.9% | 7% |
| 4 | 0.675 | 0.097 | 14.4% | 0.007 | 1.0% | 7% |
| 5 | 0.848 | 0.209 | 24.7% | 0.027 | 3.2% | 13% |
| 6+ | 0.525 | 0.111 | 21.2% | 0.012 | 2.3% | 11% |
| *DFO Survey: 1995-2006 (Ages 2-6+)* | | | | | | |
| 2 | 0.425 | 0.080 | 18.8% | 0.003 | 0.7% | 4% |
| 3 | 2.017 | 0.286 | 14.2% | 0.005 | 0.2% | 2% |
| 4 | 2.445 | 0.369 | 15.1% | 0.019 | 0.8% | 5% |
| 5 | 2.495 | 0.461 | 18.5% | 0.037 | 1.5% | 8% |
| 6+ | 2.215 | 0.436 | 19.7% | 0.029 | 1.3% | 7% |
| *NMFS Spring Survey: Yankee 41, 1973-1981 (Ages 1-6+)* | | | | | | |
| 1 | 0.007 | 0.006 | 78.8% | 0.002 | 21.0% | 27% |
| 2 | 0.077 | 0.014 | 18.1% | 0.001 | 1.3% | 7% |
| 3 | 0.098 | 0.017 | 17.2% | 0.001 | 0.9% | 5% |
| 4 | 0.096 | 0.012 | 12.0% | 0.001 | 0.8% | 7% |
| 5 | 0.076 | 0.015 | 19.7% | 0.002 | 2.1% | 11% |
| 6+ | 0.076 | 0.027 | 34.8% | 0.004 | 4.9% | 14% |
| *NMFS Spring Survey: Yankee 36, 1982-1994 (Ages 1-6+)* | | | | | | |
| 1 | 0.005 | 0.001 | 27.6% | 0.000 | 3.5% | 13% |
| 2 | 0.049 | 0.015 | 30.6% | 0.001 | 2.9% | 10% |
| 3 | 0.096 | 0.016 | 17.1% | 0.001 | 1.5% | 9% |
| 4 | 0.156 | 0.020 | 12.7% | 0.001 | 0.4% | 3% |
| 5 | 0.237 | 0.049 | 20.6% | 0.004 | 1.7% | 8% |
| 6+ | 0.441 | 0.085 | 19.2% | 0.008 | 1.9% | 10% |
| *NMFS Spring Survey: Yankee 36, 1995-2006 (Ages 1-6+)* | | | | | | |
| 1 | 0.004 | 0.001 | 32.5% | 0.000 | 3.7% | 11% |
| 2 | 0.151 | 0.019 | 12.5% | 0.001 | 0.4% | 3% |
| 3 | 0.529 | 0.090 | 17.1% | 0.005 | 0.9% | 6% |
| 4 | 0.580 | 0.105 | 18.0% | 0.010 | 1.7% | 9% |
| 5 | 0.541 | 0.127 | 23.5% | 0.015 | 2.7% | 12% |
| 6+ | 0.516 | 0.116 | 22.6% | 0.007 | 1.4% | 6% |

| | | | | | | |
|---|---|---|---|---|---|---|
| *NMFS Fall Survey: 1973-1994 (Ages 1-6+)* | | | | | | |
| 1 | 0.041 | 0.011 | 25.7% | 0.002 | 3.8% | 15% |
| 2 | 0.089 | 0.015 | 16.4% | 0.001 | 1.4% | 8% |
| 3 | 0.155 | 0.015 | 9.6% | 0.001 | 0.4% | 4% |
| 4 | 0.172 | 0.025 | 14.5% | 0.001 | 0.8% | 6% |
| 5 | 0.218 | 0.033 | 15.4% | 0.001 | 0.6% | 4% |
| 6+ | 0.315 | 0.073 | 23.1% | 0.009 | 3.0% | 13% |
| *NMFS Fall Survey: 1995-2005 (Ages 1-6+)* | | | | | | |
| 1 | 0.062 | 0.015 | 24.7% | 0.001 | 2.1% | 8% |
| 2 | 0.184 | 0.073 | 39.5% | 0.013 | 7.3% | 18% |
| 3 | 0.494 | 0.098 | 19.9% | 0.007 | 1.4% | 7% |
| 4 | 0.441 | 0.085 | 19.4% | 0.002 | 0.5% | 3% |
| 5 | 0.504 | 0.156 | 30.9% | 0.019 | 3.8% | 12% |
| 6+ | 0.428 | 0.181 | 42.3% | 0.039 | 9.2% | 22% |
| | | | | | | |
| *NMFS Scallop Survey: 1982-1994 (Age 1)* | | | | | | |
| 1 | 0.024 | 0.008 | 32.1% | 0.001 | 4.6% | 14% |
| *NMFS Scallop Survey: 1995-2005 (Age 1)* | | | | | | |
| 1 | 0.053 | 0.005 | 9.6% | 0.000 | 0.6% | 6% |

**Table 11**. Beginning of year population abundance numbers (000s) for Georges Bank yellowtail flounder from the Major Change VPA.

| | Age Group | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ | Total |
| 1973 | 29386 | 24172 | 29516 | 17301 | 6967 | 3013 | 110355 |
| 1974 | 52186 | 23735 | 15136 | 12051 | 5733 | 2392 | 111234 |
| 1975 | 70632 | 40589 | 10932 | 5010 | 3078 | 1708 | 131951 |
| 1976 | 24731 | 53646 | 9853 | 2427 | 977 | 1562 | 93196 |
| 1977 | 17280 | 19675 | 15555 | 3172 | 720 | 851 | 57252 |
| 1978 | 54436 | 13807 | 7988 | 3391 | 957 | 374 | 80952 |
| 1979 | 25511 | 35603 | 8122 | 2468 | 1074 | 560 | 73337 |
| 1980 | 24034 | 20596 | 19711 | 3267 | 748 | 240 | 68595 |
| 1981 | 62999 | 19390 | 13269 | 7498 | 1302 | 221 | 104679 |
| 1982 | 22847 | 51482 | 14885 | 5537 | 1783 | 156 | 96691 |
| 1983 | 6582 | 16754 | 25939 | 5517 | 1515 | 345 | 56653 |
| 1984 | 10842 | 4755 | 6579 | 6473 | 2305 | 486 | 31441 |
| 1985 | 16748 | 8413 | 2089 | 1379 | 871 | 137 | 29637 |
| 1986 | 8473 | 12837 | 2990 | 767 | 402 | 223 | 25692 |
| 1987 | 9199 | 6775 | 4801 | 1439 | 281 | 201 | 22696 |
| 1988 | 22877 | 7390 | 2617 | 1153 | 309 | 72 | 34419 |
| 1989 | 9732 | 18280 | 3364 | 771 | 198 | 54 | 32399 |
| 1990 | 11542 | 7796 | 13006 | 1749 | 250 | 47 | 34390 |
| 1991 | 22787 | 9241 | 4485 | 4419 | 562 | 104 | 41598 |
| 1992 | 18341 | 18058 | 7433 | 2335 | 956 | 67 | 47189 |
| 1993 | 13958 | 12841 | 6612 | 3427 | 606 | 134 | 37579 |
| 1994 | 10659 | 6742 | 9264 | 2447 | 749 | 157 | 30018 |
| 1995 | 11123 | 8673 | 4232 | 1734 | 371 | 83 | 26216 |
| 1996 | 13178 | 9051 | 6891 | 2185 | 543 | 53 | 31901 |
| 1997 | 18428 | 10740 | 6899 | 3916 | 947 | 229 | 41160 |
| 1998 | 23888 | 15033 | 8121 | 4298 | 1575 | 348 | 53264 |
| 1999 | 25520 | 19500 | 10959 | 3764 | 1616 | 470 | 61829 |
| 2000 | 20981 | 20861 | 12641 | 5760 | 1536 | 775 | 62554 |
| 2001 | 23703 | 17038 | 13623 | 5008 | 1938 | 1028 | 62338 |
| 2002 | 15907 | 19150 | 11191 | 4373 | 1588 | 1078 | 53287 |
| 2003 | 17128 | 12792 | 11690 | 5708 | 1931 | 1712 | 50962 |
| 2004 | 11877 | 13879 | 7047 | 5132 | 2618 | 1916 | 42469 |
| 2005 | 9193 | 9654 | 10159 | 2656 | 613 | 291 | 32566 |
| 2006 | | 7478 | 6412 | 4418 | 552 | 188 | |

**Table 12**. Fishing mortality rate for Georges Bank yellowtail from the Major Change VPA.

| | Age Group | | | | | |
|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6+ |
| 1973 | 0.014 | 0.268 | 0.696 | 0.905 | 0.905 | 0.905 |
| 1974 | 0.051 | 0.575 | 0.906 | 1.165 | 1.165 | 1.165 |
| 1975 | 0.075 | 1.216 | 1.305 | 1.435 | 1.435 | 1.435 |
| 1976 | 0.029 | 1.038 | 0.933 | 1.015 | 1.015 | 1.015 |
| 1977 | 0.024 | 0.701 | 1.323 | 0.999 | 0.999 | 0.999 |
| 1978 | 0.225 | 0.331 | 0.975 | 0.950 | 0.950 | 0.950 |
| 1979 | 0.014 | 0.391 | 0.711 | 0.994 | 0.994 | 0.994 |
| 1980 | 0.015 | 0.240 | 0.766 | 0.720 | 0.720 | 0.720 |
| 1981 | 0.002 | 0.064 | 0.674 | 1.237 | 1.237 | 1.237 |
| 1982 | 0.110 | 0.485 | 0.792 | 1.096 | 1.096 | 1.096 |
| 1983 | 0.125 | 0.735 | 1.188 | 0.673 | 0.673 | 0.673 |
| 1984 | 0.054 | 0.623 | 1.363 | 1.805 | 1.805 | 1.805 |
| 1985 | 0.066 | 0.834 | 0.802 | 1.032 | 1.032 | 1.032 |
| 1986 | 0.024 | 0.784 | 0.531 | 0.804 | 0.804 | 0.804 |
| 1987 | 0.019 | 0.751 | 1.227 | 1.338 | 1.338 | 1.338 |
| 1988 | 0.024 | 0.587 | 1.022 | 1.561 | 1.561 | 1.561 |
| 1989 | 0.022 | 0.140 | 0.454 | 0.925 | 0.925 | 0.925 |
| 1990 | 0.022 | 0.353 | 0.879 | 0.935 | 0.935 | 0.935 |
| 1991 | 0.033 | 0.018 | 0.453 | 1.331 | 1.331 | 1.331 |
| 1992 | 0.156 | 0.805 | 0.574 | 1.150 | 1.150 | 1.150 |
| 1993 | 0.528 | 0.127 | 0.794 | 1.321 | 1.321 | 1.321 |
| 1994 | 0.006 | 0.266 | 1.475 | 1.686 | 1.686 | 1.686 |
| 1995 | 0.006 | 0.030 | 0.461 | 0.961 | 0.961 | 0.961 |
| 1996 | 0.005 | 0.071 | 0.365 | 0.635 | 0.635 | 0.635 |
| 1997 | 0.004 | 0.080 | 0.273 | 0.711 | 0.711 | 0.711 |
| 1998 | 0.003 | 0.116 | 0.569 | 0.778 | 0.778 | 0.778 |
| 1999 | 0.002 | 0.233 | 0.443 | 0.696 | 0.696 | 0.696 |
| 2000 | 0.008 | 0.226 | 0.726 | 0.889 | 0.889 | 0.889 |
| 2001 | 0.013 | 0.220 | 0.936 | 0.948 | 0.948 | 0.948 |
| 2002 | 0.018 | 0.294 | 0.473 | 0.618 | 0.618 | 0.618 |
| 2003 | 0.010 | 0.396 | 0.623 | 0.579 | 0.579 | 0.579 |
| 2004 | 0.007 | 0.112 | 0.776 | 1.924 | 1.924 | 1.924 |
| 2005 | 0.007 | 0.209 | 0.633 | 1.371 | 1.371 | 1.371 |

**Table 13**. Beginning of year weight (kg) at age for Georges Bank yellowtail. The 2006 values are set equal to the average of the 2003-2005 values.

| | Age | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 6+ |
| 1973 | 0.01 | 0.23 | 0.401 | 0.493 | 0.564 | 0.645 | 0.856 | 1.096 | 1.1 | 1.3 | 1.4 | 1.5 | 0.704 |
| 1974 | 0.01 | 0.23 | 0.415 | 0.530 | 0.598 | 0.660 | 0.790 | 1.150 | 1.1 | 1.3 | 1.4 | 1.5 | 0.755 |
| 1975 | 0.01 | 0.23 | 0.410 | 0.524 | 0.613 | 0.684 | 0.707 | 0.769 | 1.1 | 1.3 | 1.4 | 1.5 | 0.715 |
| 1976 | 0.01 | 0.23 | 0.415 | 0.557 | 0.642 | 0.709 | 0.768 | 0.780 | 1.1 | 1.3 | 1.4 | 1.5 | 0.767 |
| 1977 | 0.01 | 0.23 | 0.404 | 0.587 | 0.704 | 0.800 | 0.913 | 0.928 | 1.1 | 1.3 | 1.4 | 1.5 | 0.885 |
| 1978 | 0.01 | 0.23 | 0.418 | 0.601 | 0.713 | 0.839 | 0.902 | 1.017 | 1.1 | 1.3 | 1.4 | 1.5 | 0.918 |
| 1979 | 0.01 | 0.23 | 0.381 | 0.578 | 0.713 | 0.823 | 0.948 | 0.926 | 1.1 | 1.3 | 1.4 | 1.5 | 0.900 |
| 1980 | 0.01 | 0.23 | 0.403 | 0.551 | 0.732 | 0.878 | 1.010 | 1.095 | 1.1 | 1.3 | 1.4 | 1.5 | 0.907 |
| 1981 | 0.01 | 0.23 | 0.397 | 0.546 | 0.681 | 0.818 | 0.940 | 1.390 | 1.1 | 1.3 | 1.4 | 1.5 | 0.837 |
| 1982 | 0.01 | 0.23 | 0.403 | 0.564 | 0.675 | 0.868 | 0.923 | 1.072 | 1.1 | 1.3 | 1.4 | 1.5 | 0.895 |
| 1983 | 0.01 | 0.23 | 0.364 | 0.543 | 0.694 | 0.853 | 1.035 | 1.163 | 1.1 | 1.3 | 1.4 | 1.5 | 0.907 |
| 1984 | 0.01 | 0.23 | 0.335 | 0.470 | 0.627 | 0.741 | 0.954 | 1.018 | 1.1 | 1.3 | 1.4 | 1.5 | 0.796 |
| 1985 | 0.01 | 0.23 | 0.347 | 0.493 | 0.604 | 0.723 | 0.735 | 1.019 | 1.1 | 1.3 | 1.4 | 1.5 | 0.724 |
| 1986 | 0.01 | 0.23 | 0.442 | 0.583 | 0.740 | 0.844 | 0.876 | 0.954 | 1.1 | 1.3 | 1.4 | 1.5 | 0.867 |
| 1987 | 0.01 | 0.23 | 0.423 | 0.606 | 0.727 | 0.921 | 0.904 | 0.856 | 1.1 | 1.3 | 1.4 | 1.5 | 0.936 |
| 1988 | 0.01 | 0.23 | 0.425 | 0.604 | 0.758 | 0.904 | 0.927 | 1.077 | 1.1 | 1.3 | 1.4 | 1.5 | 0.925 |
| 1989 | 0.01 | 0.23 | 0.413 | 0.633 | 0.776 | 0.905 | 1.105 | 0.988 | 1.1 | 1.3 | 1.4 | 1.5 | 0.987 |
| 1990 | 0.01 | 0.23 | 0.359 | 0.552 | 0.706 | 0.826 | 1.013 | 1.135 | 1.1 | 1.3 | 1.4 | 1.5 | 0.866 |
| 1991 | 0.01 | 0.23 | 0.327 | 0.438 | 0.650 | 0.767 | 1.014 | 1.078 | 1.1 | 1.3 | 1.4 | 1.5 | 0.782 |
| 1992 | 0.01 | 0.23 | 0.294 | 0.441 | 0.562 | 0.891 | 0.978 | 1.304 | 1.1 | 1.3 | 1.4 | 1.5 | 0.917 |
| 1993 | 0.01 | 0.23 | 0.333 | 0.428 | 0.545 | 0.741 | 1.114 | 1.084 | 1.1 | 1.3 | 1.4 | 1.5 | 0.767 |
| 1994 | 0.01 | 0.23 | 0.315 | 0.422 | 0.557 | 0.676 | 0.781 | 1.192 | 1.1 | 1.3 | 1.4 | 1.5 | 0.702 |
| 1995 | 0.01 | 0.23 | 0.300 | 0.401 | 0.523 | 0.689 | 0.807 | 0.620 | 1.1 | 1.3 | 1.4 | 1.5 | 0.760 |
| 1996 | 0.01 | 0.23 | 0.318 | 0.445 | 0.578 | 0.731 | 0.902 | 1.018 | 1.1 | 1.3 | 1.4 | 1.5 | 0.836 |
| 1997 | 0.01 | 0.23 | 0.351 | 0.470 | 0.623 | 0.777 | 0.897 | 1.121 | 1.1 | 1.3 | 1.4 | 1.5 | 0.889 |
| 1998 | 0.01 | 0.23 | 0.378 | 0.478 | 0.609 | 0.789 | 0.883 | 1.024 | 1.1 | 1.3 | 1.4 | 1.5 | 0.812 |
| 1999 | 0.01 | 0.23 | 0.404 | 0.534 | 0.641 | 0.788 | 0.964 | 1.181 | 1.1 | 1.3 | 1.4 | 1.5 | 0.819 |
| 2000 | 0.01 | 0.23 | 0.421 | 0.555 | 0.697 | 0.832 | 0.958 | 1.013 | 1.1 | 1.3 | 1.4 | 1.5 | 0.861 |
| 2001 | 0.01 | 0.23 | 0.416 | 0.548 | 0.704 | 0.879 | 0.967 | 1.139 | 1.1 | 1.3 | 1.4 | 1.5 | 0.932 |
| 2002 | 0.01 | 0.23 | 0.410 | 0.552 | 0.719 | 0.891 | 1.037 | 1.145 | 1.1 | 1.3 | 1.4 | 1.5 | 0.972 |
| 2003 | 0.01 | 0.23 | 0.427 | 0.565 | 0.745 | 0.885 | 1.008 | 1.104 | 1.1 | 1.3 | 1.4 | 1.5 | 0.974 |
| 2004 | 0.01 | 0.23 | 0.396 | 0.526 | 0.687 | 0.857 | 0.973 | 1.116 | 1.1 | 1.3 | 1.4 | 1.5 | 0.922 |
| 2005 | 0.01 | 0.23 | 0.361 | 0.511 | 0.666 | 0.835 | 0.933 | 1.105 | 1.1 | 1.3 | 1.4 | 1.5 | 0.879 |
| 2006 | 0.01 | 0.23 | 0.395 | 0.534 | 0.699 | 0.859 | 0.971 | 1.109 | 1.1 | 1.3 | 1.4 | 1.5 | 0.925 |

**Table 14**. Beginning of year biomass (mt) and spawning stock biomass (mt) for Georges Bank yellowtail from the Major Change VPA.

| | Major Change VPA | | |
|---|---|---|---|
| | Beginning Biomass | | |
| Year | 1+ | 3+ | SSB |
| 1973 | 32275 | 26422 | 21899 |
| 1974 | 23884 | 17903 | 14772 |
| 1975 | 20261 | 10219 | 8967 |
| 1976 | 19850 | 7264 | 9950 |
| 1977 | 14108 | 9410 | 8353 |
| 1978 | 10119 | 6400 | 6160 |
| 1979 | 14234 | 5790 | 8424 |
| 1980 | 15479 | 10501 | 10902 |
| 1981 | 15518 | 10429 | 10411 |
| 1982 | 22534 | 10465 | 13412 |
| 1983 | 17727 | 13808 | 11347 |
| 1984 | 8277 | 7075 | 4269 |
| 1985 | 4133 | 2031 | 3506 |
| 1986 | 5296 | 2259 | 4608 |
| 1987 | 4944 | 3294 | 3486 |
| 1988 | 4037 | 2109 | 3044 |
| 1989 | 6386 | 2085 | 6647 |
| 1990 | 7765 | 5856 | 5717 |
| 1991 | 6204 | 3850 | 4519 |
| 1992 | 8150 | 3814 | 4597 |
| 1993 | 7195 | 4102 | 4239 |
| 1994 | 6134 | 4477 | 2907 |
| 1995 | 4327 | 2221 | 2648 |
| 1996 | 5738 | 3525 | 4340 |
| 1997 | 7710 | 5055 | 5665 |
| 1998 | 10060 | 6363 | 6981 |
| 1999 | 12601 | 7861 | 9543 |
| 2000 | 15270 | 10263 | 10444 |
| 2001 | 14885 | 10729 | 9444 |
| 2002 | 13751 | 9187 | 10478 |
| 2003 | 14432 | 11319 | 10393 |
| 2004 | 12368 | 9057 | 6377 |
| 2005 | 7999 | 5687 | 5441 |
| 2006 | | 5450 | |

**Table 15**. Deterministic projection input assumptions and results for Georges Bank yellowtail for 2007 at $F_{Ref}$ using the Major Change VPA.

| Year | Age Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6+ | 1+ | 3+ |
| *Beginning of Year Population Numbers (000s)* | | | | | | | | |
| 2006 | 17142 | 7478 | 6412 | 4418 | 552 | 188 | | |
| 2007 | 17142 | 13962 | 5246 | 3389 | 1570 | 263 | | |
| 2008 | 17142 | 14012 | 10914 | 3767 | 2161 | 1169 | | |
| *Partial Recruitment to the Fishery* | | | | | | | | |
| | 0.006 | 0.185 | 0.524 | 1.000 | 1.000 | 1.000 | | |
| *Fishing Mortality* | | | | | | | | |
| 2006 | 0.005 | 0.155 | 0.438 | 0.834 | 0.834 | 0.834 | | |
| 2007 | 0.002 | 0.046 | 0.131 | 0.250 | 0.250 | 0.250 | | |
| *Weight at beginning of year for population (kg)* | | | | | | | | |
| | 0.010 | 0.230 | 0.395 | 0.534 | 0.699 | 0.925 | | |
| *Maturity* | | | *Fraction of Z before Spawning =* | | | 0.4167 | | |
| | 0 | 0.52 | 0.86 | 1 | 1 | 1 | | |
| *Beginning of Year Projected Population Biomass (mt)* | | | | | | | | |
| 2006 | 171 | 1720 | 2531 | 2359 | 386 | 174 | 7341 | 5450 |
| 2007 | 171 | 3211 | 2070 | 1810 | 1098 | 243 | 8604 | 5221 |
| 2008 | 171 | 3223 | 4307 | 2012 | 1511 | 1081 | 12305 | 8911 |
| *Spawning Stock Biomass (mt)* | | | | | | | | |
| 2006 | 0 | 1114 | 1916 | 1754 | 277 | 121 | 5182 | |
| 2007 | 0 | 2176 | 1781 | 1716 | 1005 | 217 | 6895 | |
| *Projected Catch Numbers (000s)* | | | | | | | | |
| 2006 | 81 | 973 | 2075 | 2297 | 287 | 98 | | |
| 2007 | 24 | 573 | 585 | 682 | 316 | 53 | | |
| *Average weight for catch (kg)* | | | | | | | | |
| | 0.183 | 0.332 | 0.453 | 0.611 | 0.772 | 0.993 | | |
| *Projected Yield (mt)* | | | | | | | | |
| 2006 | 15 | 323 | 940 | 1403 | 222 | 97 | **3000** | |
| 2007 | 4 | 190 | 265 | 417 | 244 | 53 | **1173** | |

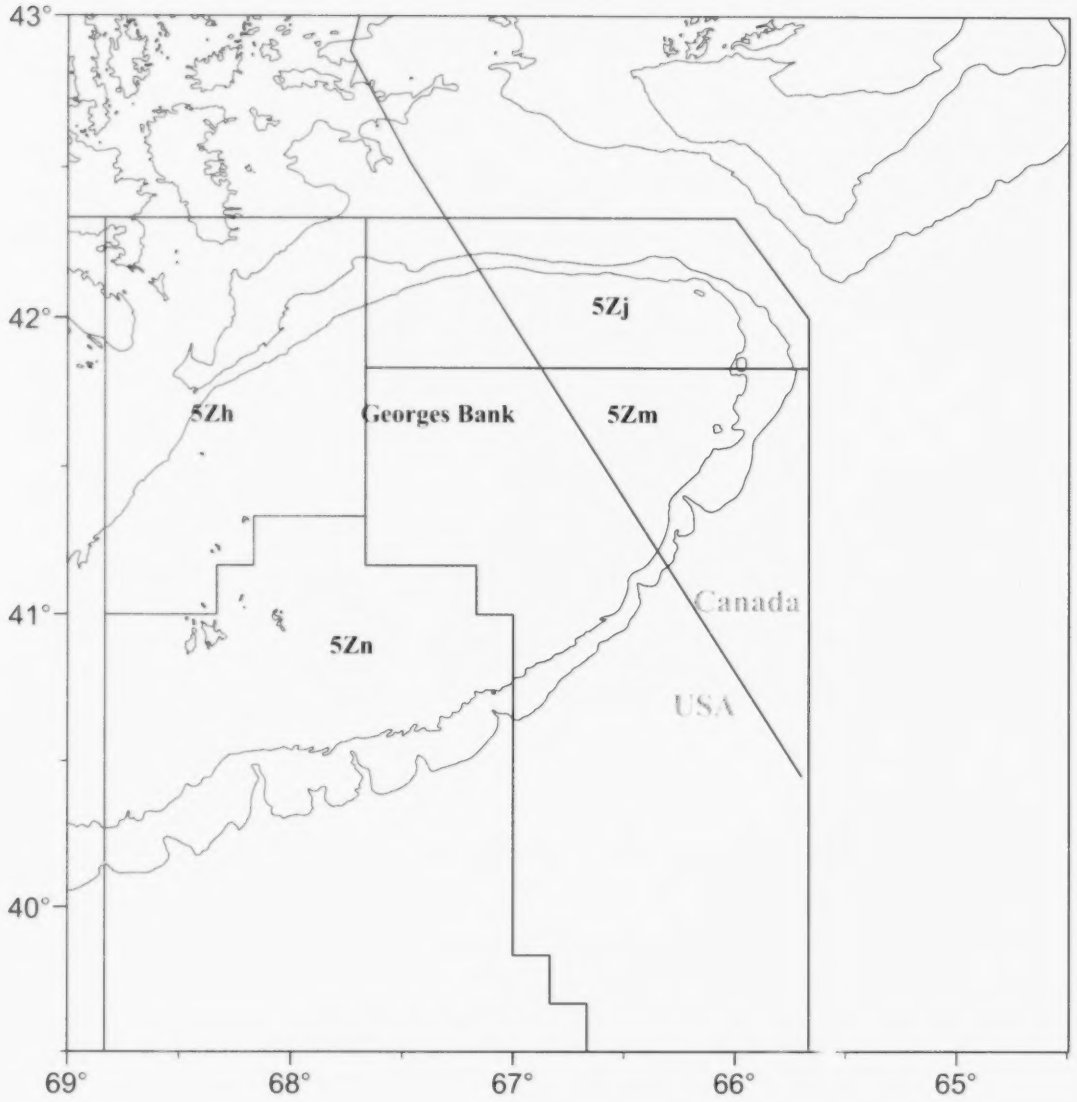



**Figure 1a**. Location of statistical unit areas for Canadian fisheries in NAFO Subdivision 5Ze.

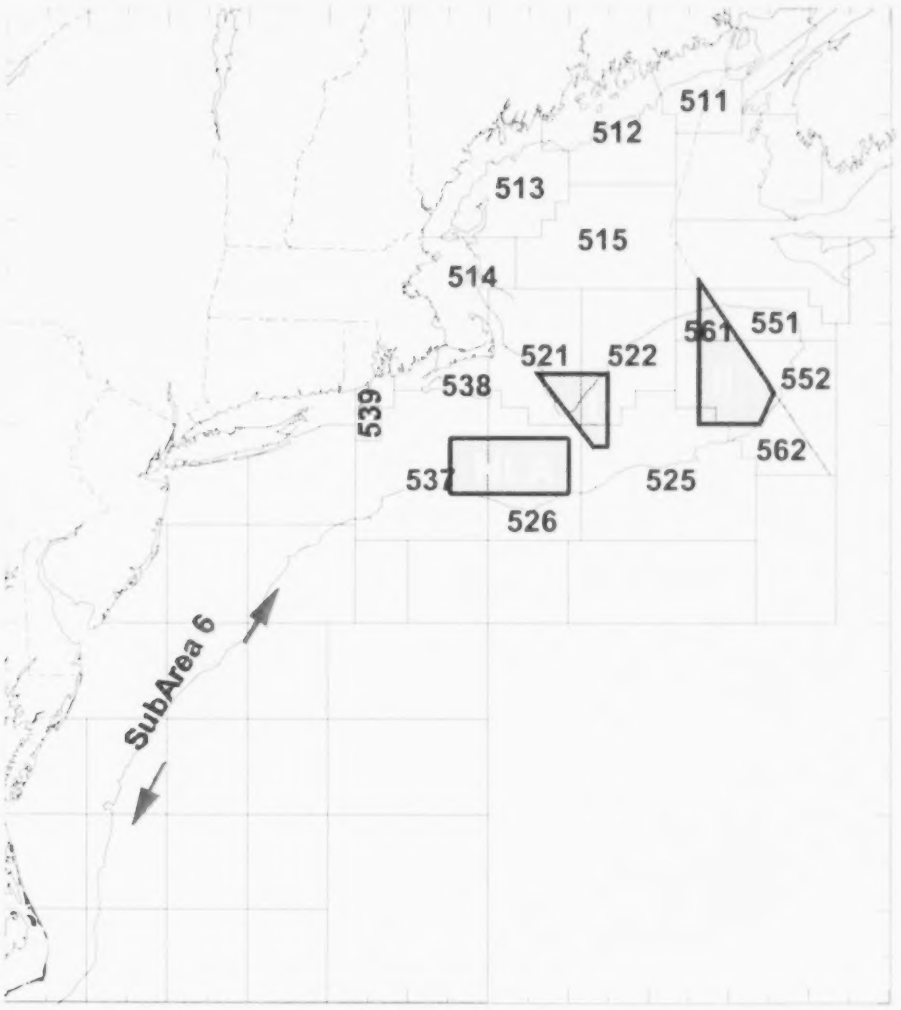



**Figure 1b**. Statistical areas used for monitoring northeast U.S. fisheries. Catches from areas 522, 525, 551, 552, 561 and 562 are included in the Georges Bank yellowtail flounder assessment. Shaded areas have been closed to fishing year-round since 1994, with exceptions.

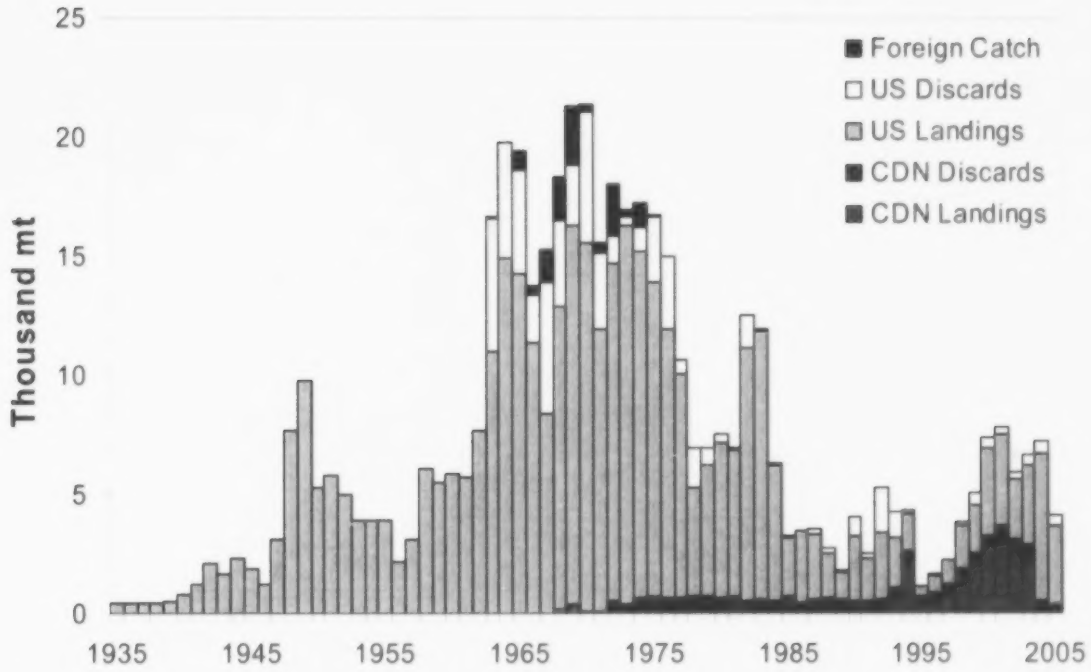



**Figure 2**. Landings (including discards) of Georges Bank yellowtail flounder by nation, 1935-2005.

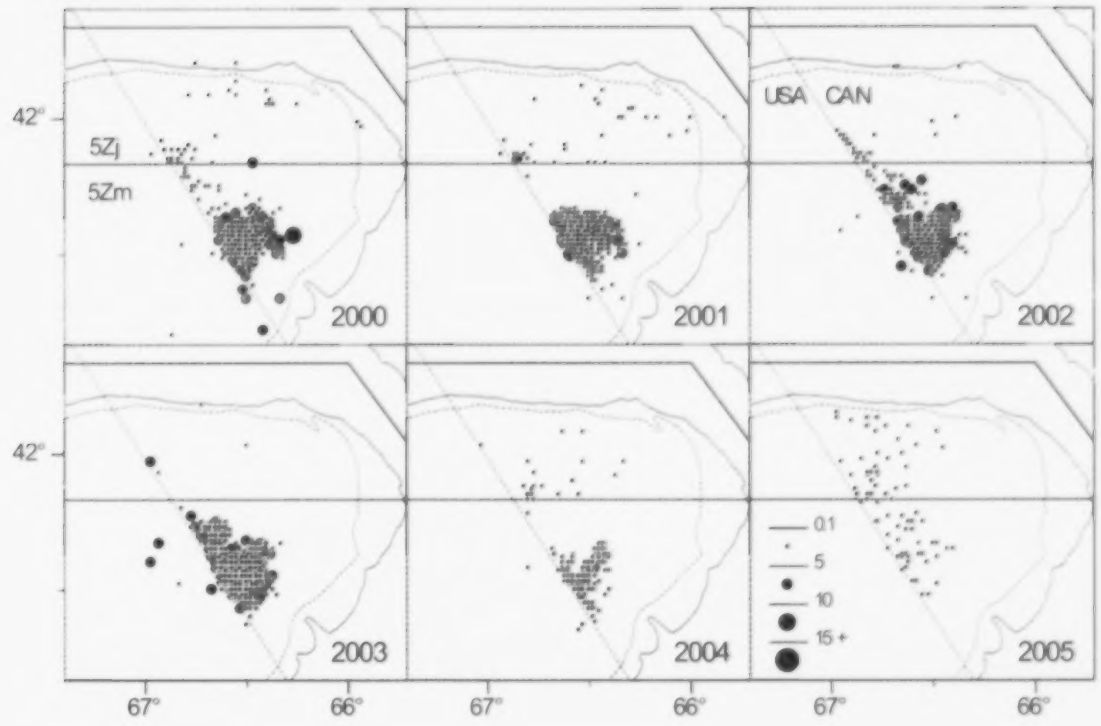



**Figure 3**. Distribution of Canadian mobile gear (TC 1-3) yellowtail flounder catches from commercial landings data for 2000-2003 where trip landings were greater than 0.5 mt. For 2004 and 2005, catches > 0.1 mt are shown. Expanding symbols represent metric tons of catch.

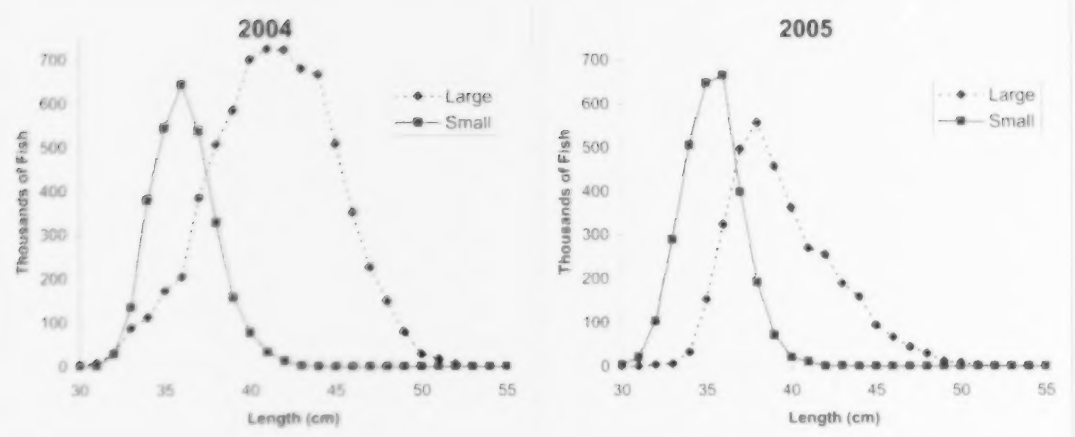



**Figure 4**. US landings of Georges Bank yellowtail by market category.

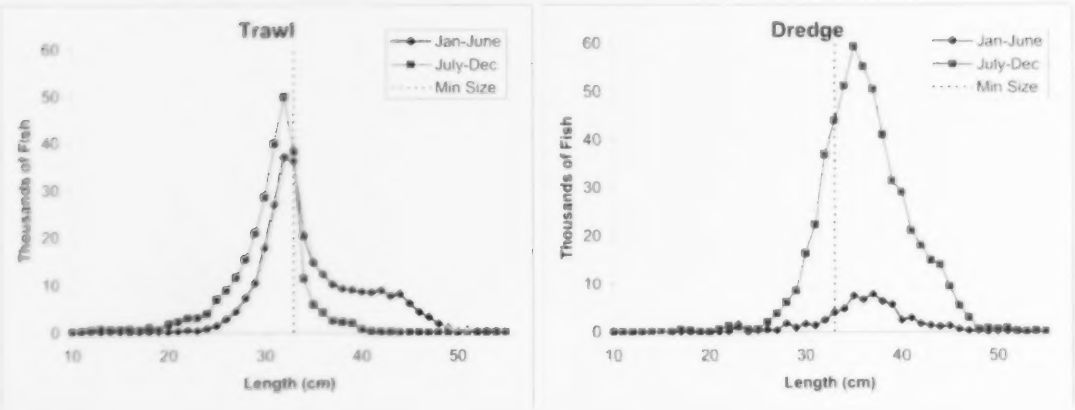



**Figure 5**. US discard length frequencies by gear and half year.

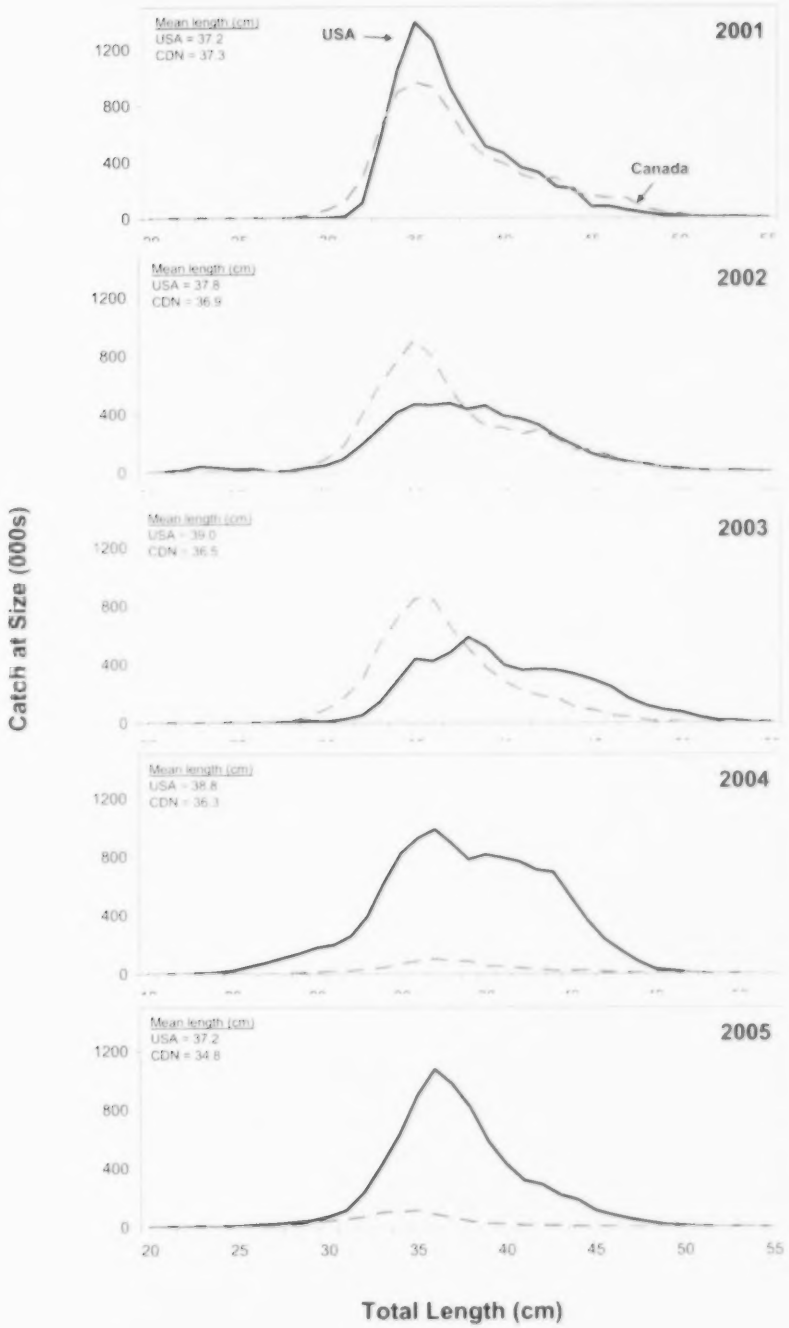



**Figure 6**. Comparison of Georges Bank yellowtail flounder catch at size from the Canadian and USA fisheries 2001-2005.

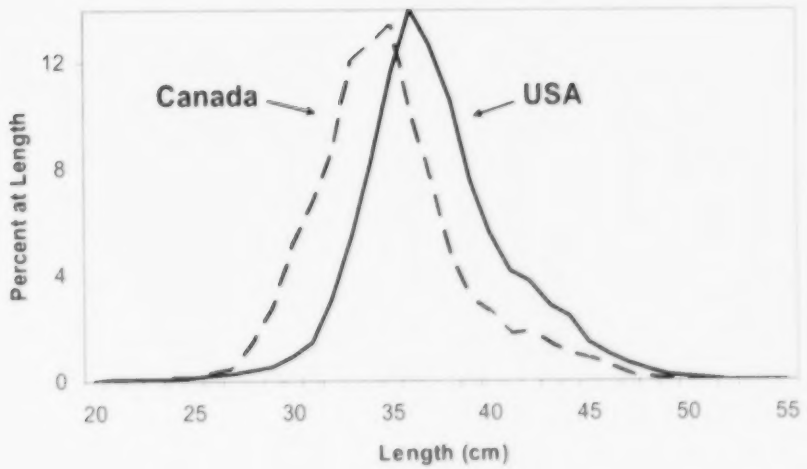
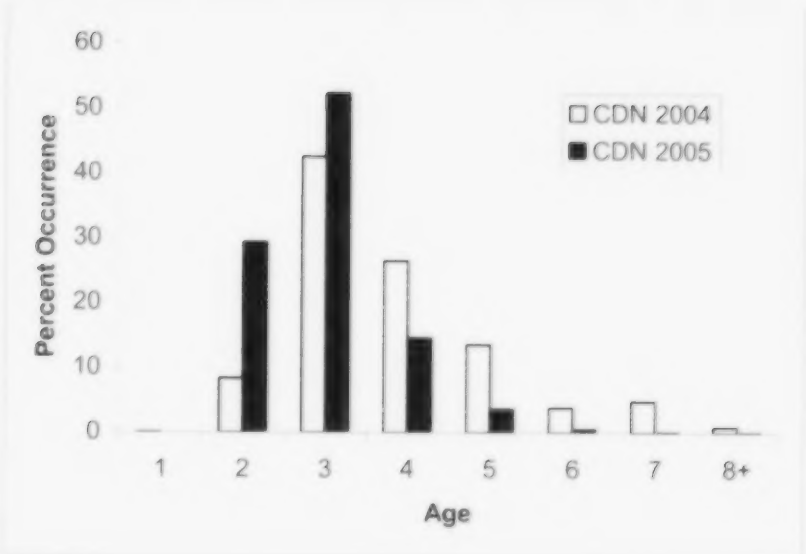



**Figure 7**. Comparison of Georges Bank yellowtail flounder proportion at size from the Canadian and USA fisheries in 2005.



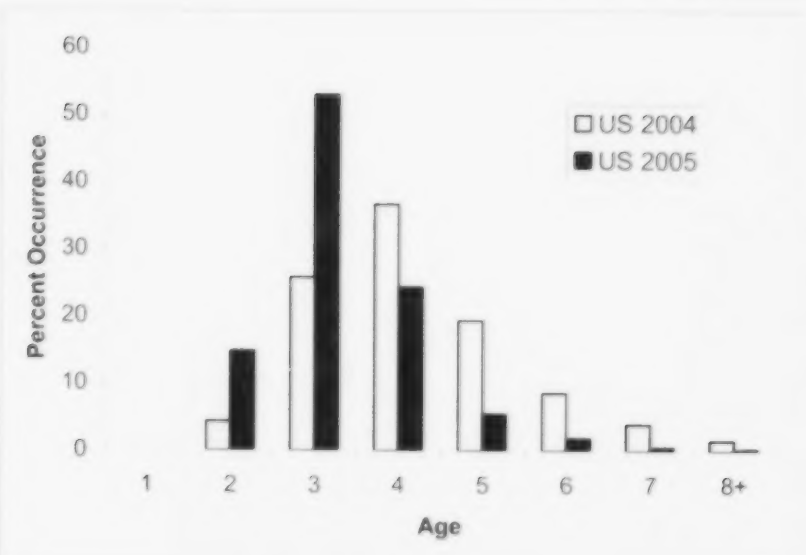




**Figure 8**. Comparison of 2004 and 2005 Georges Bank yellowtail flounder landings at age for Canada (upper panel) and the USA (lower panel). (Note: discards for both nations are not included).

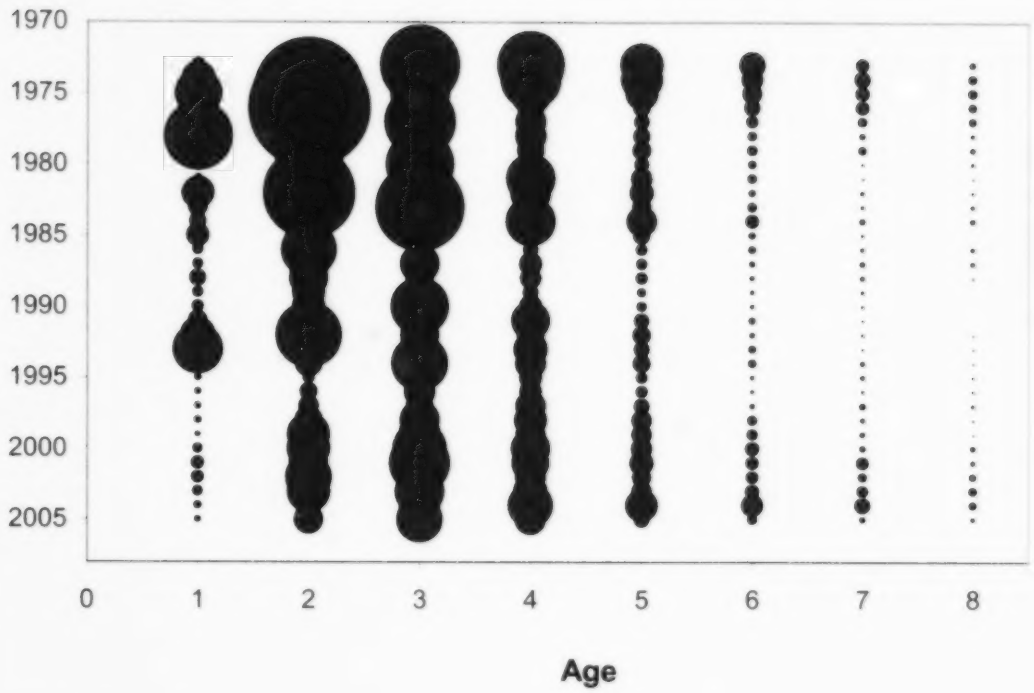



**Figure 9**. Catch at age for Georges Bank yellowtail flounder, Canadian and USA fisheries combined, 1973-2005. (The area of the bubble is proportional to the magnitude of the catch).

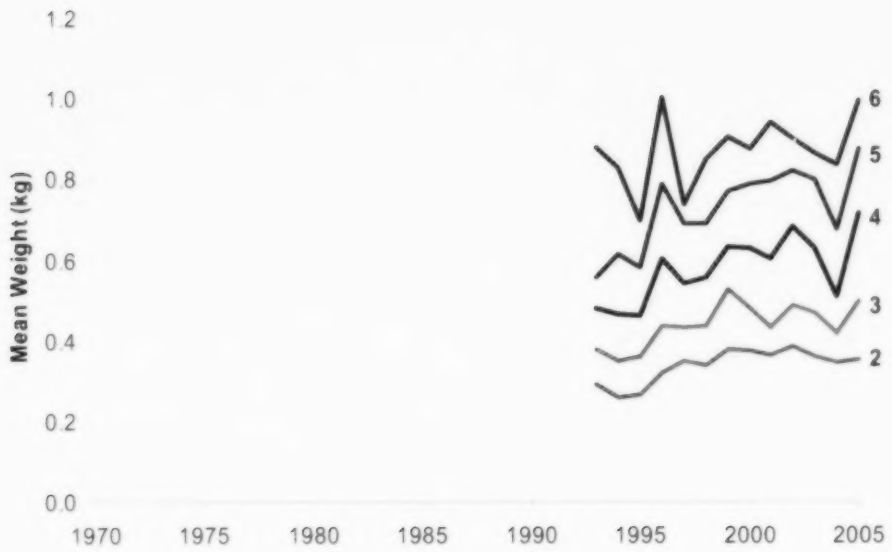



**Figure 10**. Mean weight (kg) at age for yellowtail flounder from landings by the Canadian commercial fishery, 1993-2005.

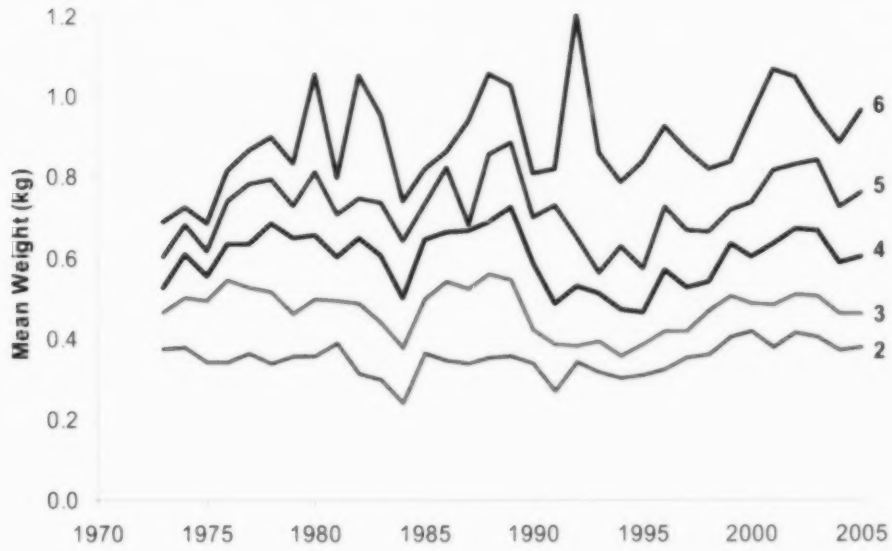



**Figure 11**. Mean weight (kg) at age for yellowtail flounder from landings by the US commercial fishery, 1973-2005.

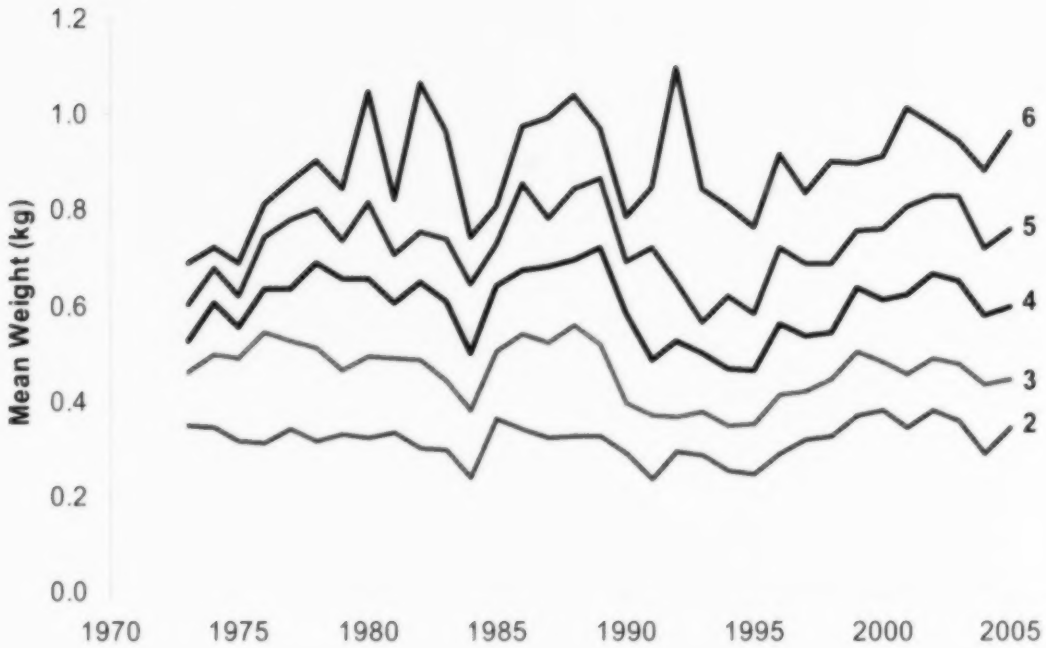



**Figure 12**. Trends in mean weight at age from the Georges Bank yellowtail fishery, 1973 to 2005 (Canada and USA combined including discards).

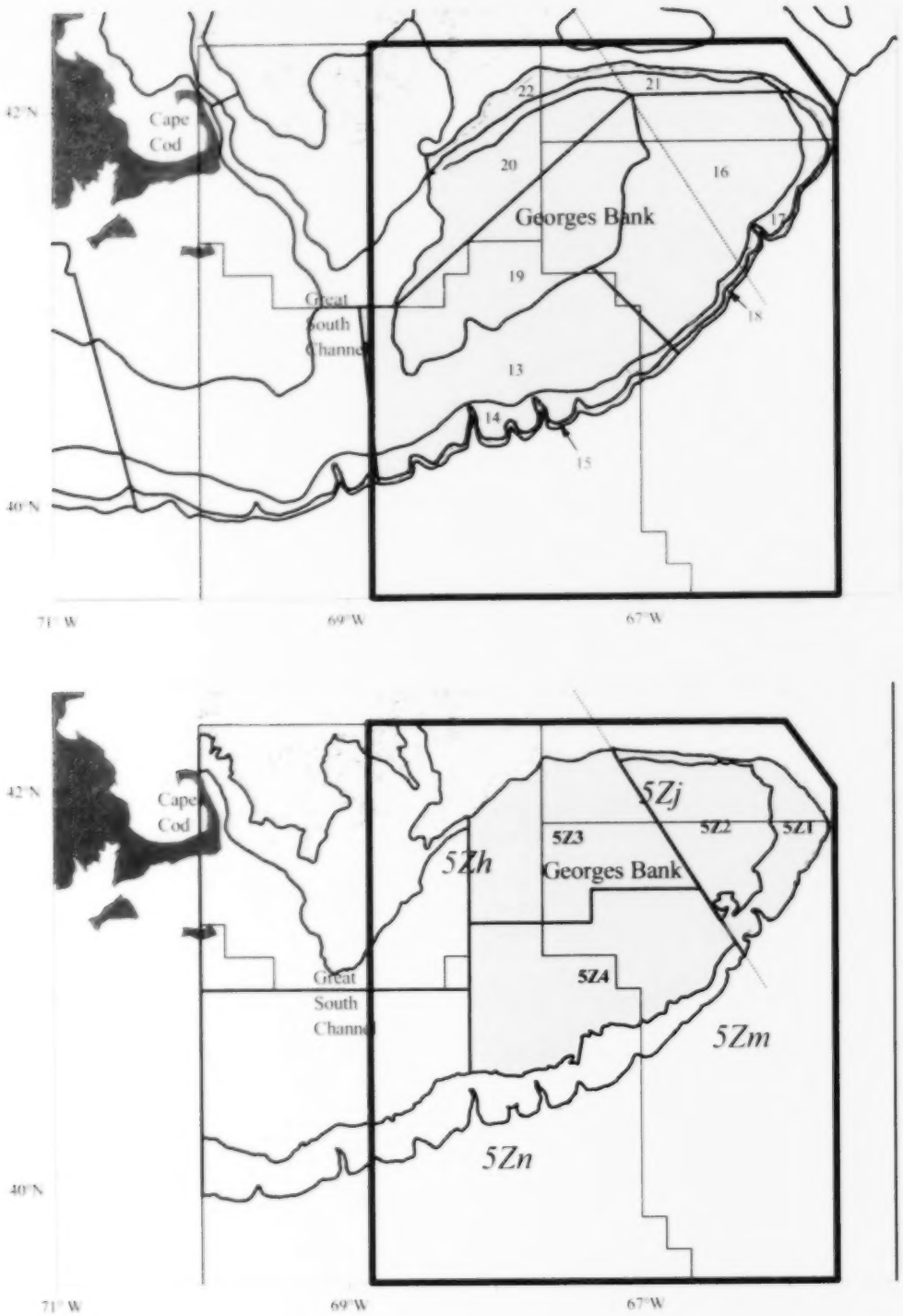



**Figure 13**. NMFS (top) and DFO (bottom) strata used to derive research survey abundance indices for Georges Bank groundfish surveys. Note NMFS stratum 22 is not used in assessment.

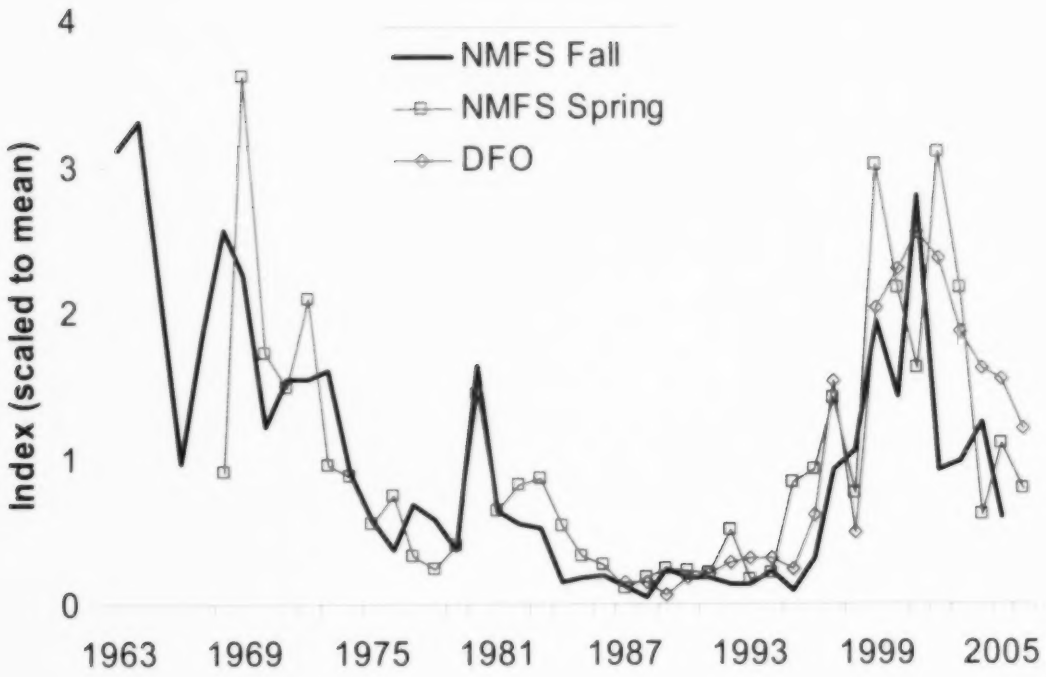



**Figure 14**. NMFS and DFO spring and NMFS fall survey biomass indices for yellowtail flounder on Georges Bank.

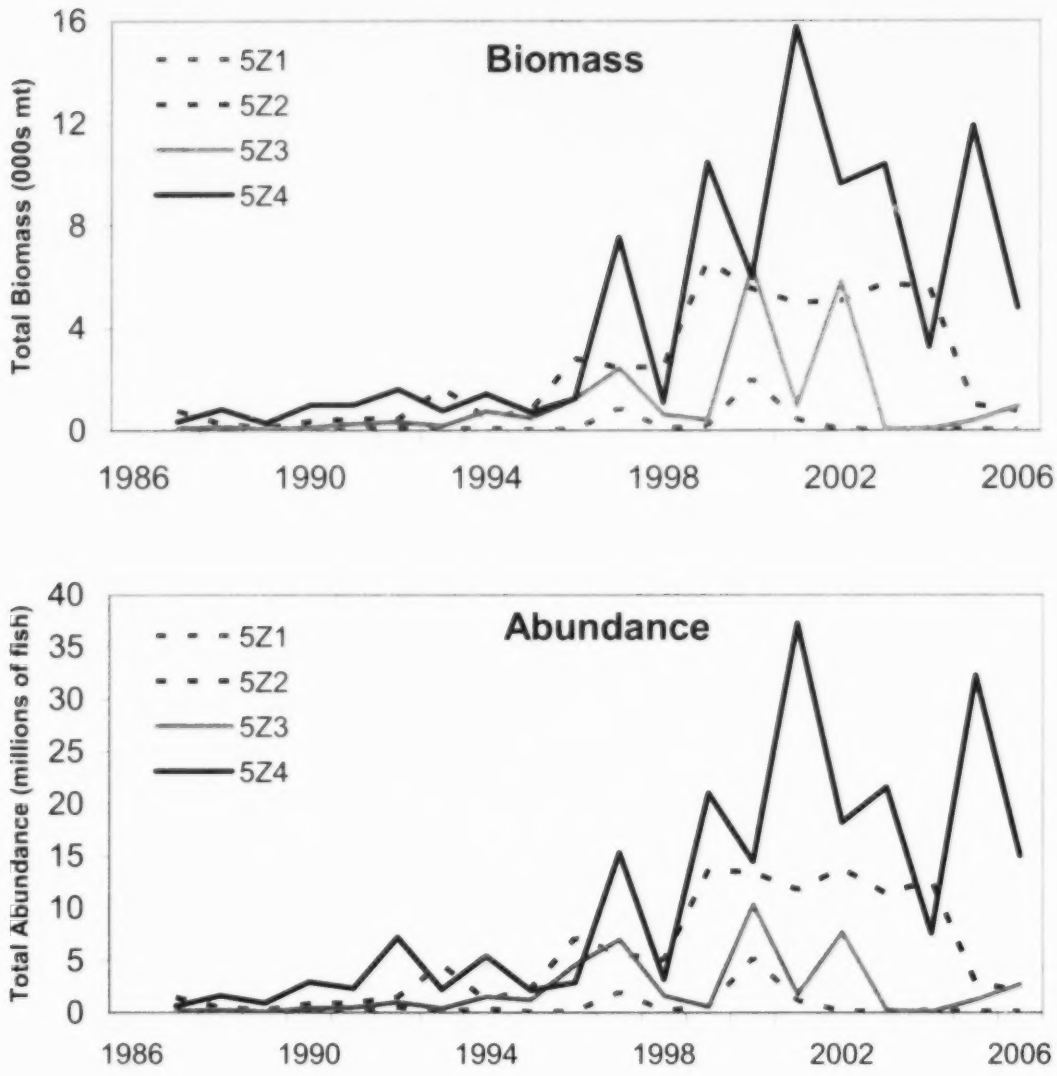



**Figure 15**. DFO spring survey estimates of total biomass (top panel) and total number (bottom panel) by stratum area for yellowtail flounder on Georges Bank, 1987-2005.

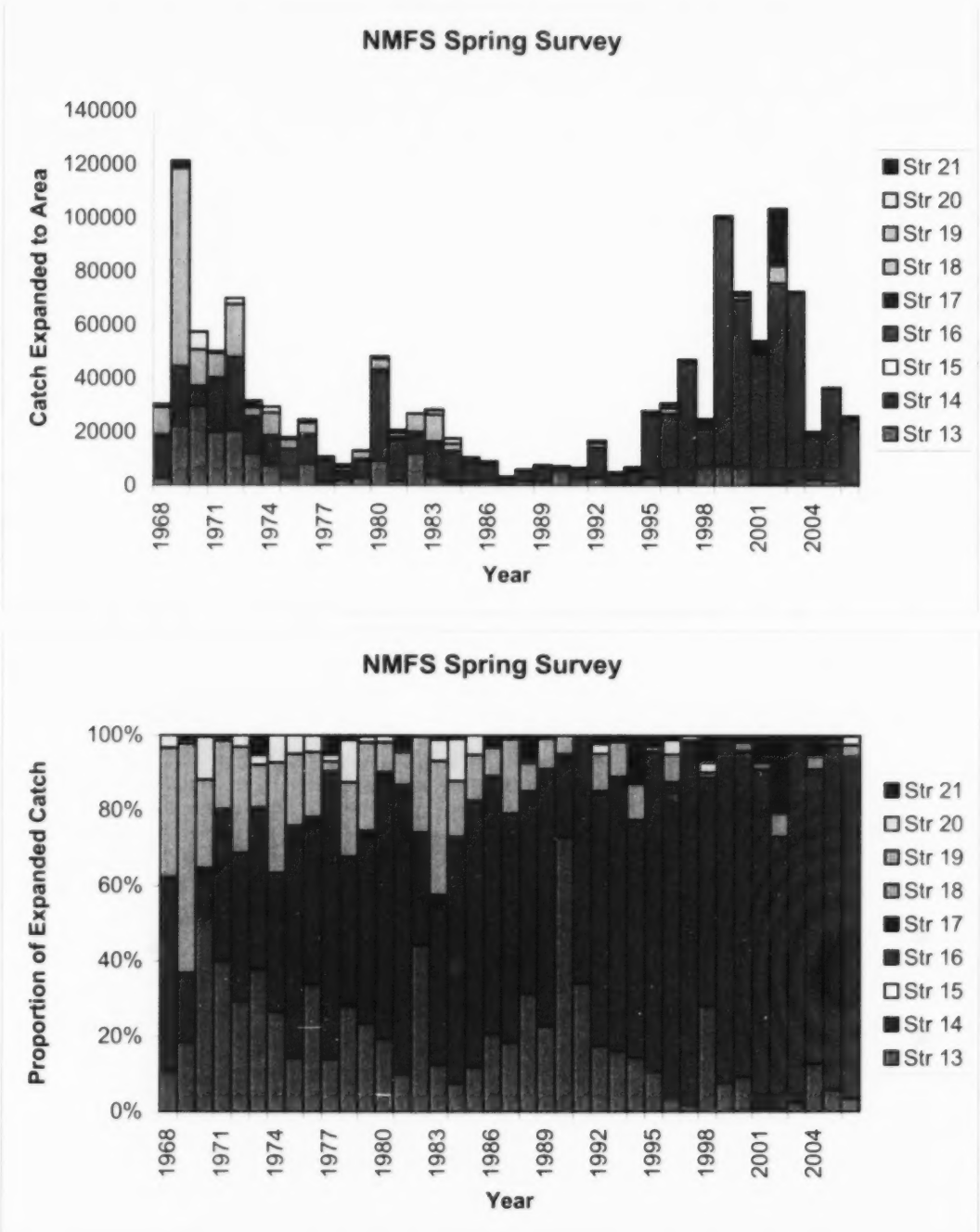



**Figure 16**. NMFS spring survey estimates of total biomass (top panel) and proportion of expanded catch (bottom panel) by stratum for yellowtail flounder on Georges Bank, 1968-2006.

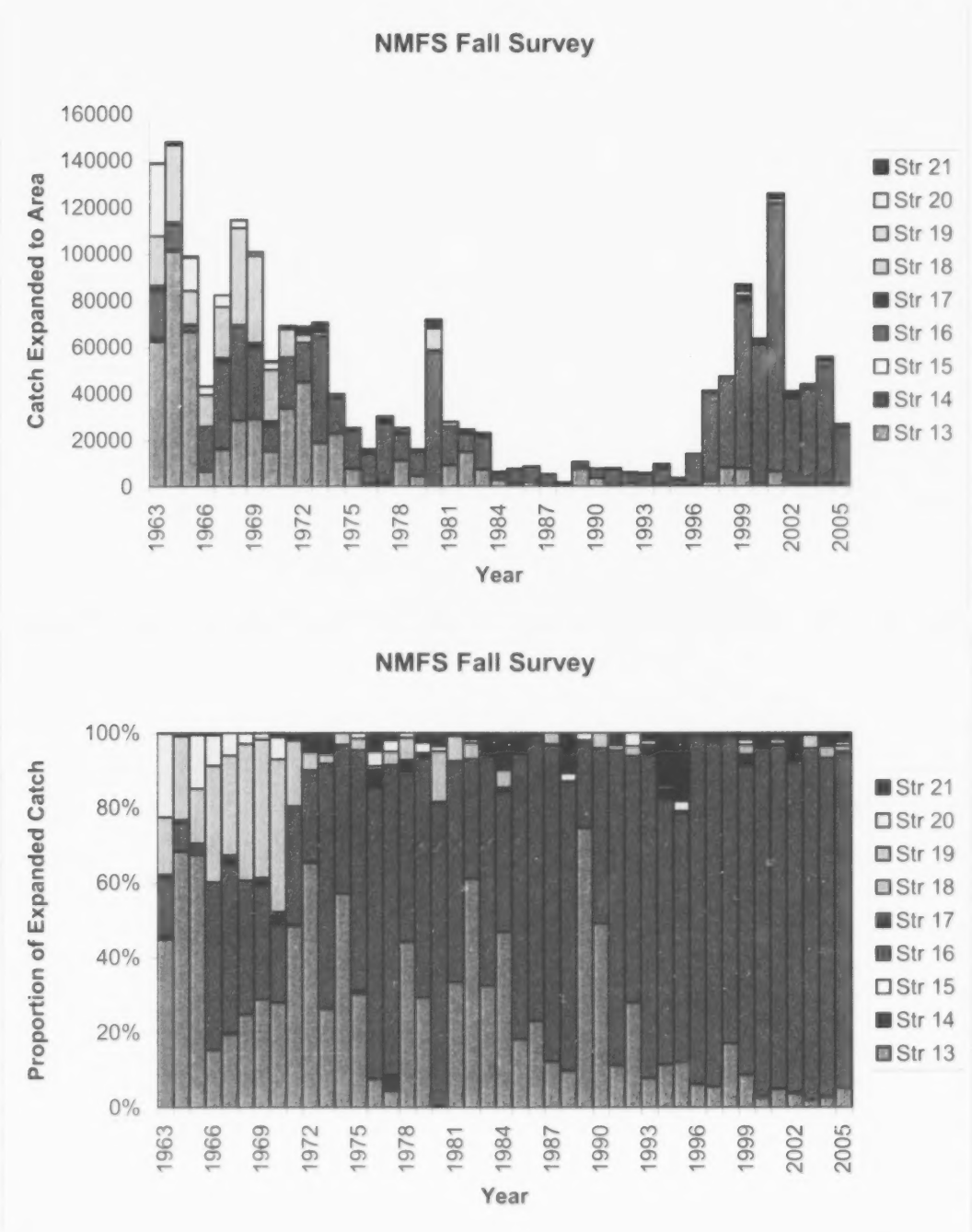



**Figure 17**. NMFS fall survey estimates of total biomass (top panel) and proportion of expanded catch (bottom panel) by stratum for yellowtail flounder on Georges Bank, 1963-2005.

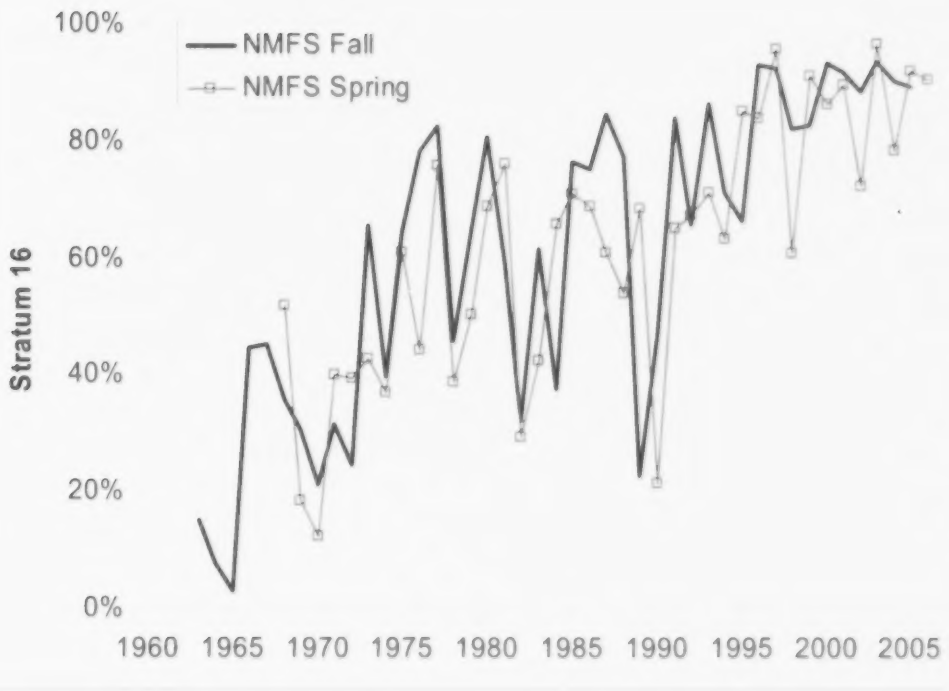



**Figure 18**. Proportion of survey biomass for yellowtail flounder on Georges Bank found in stratum 16 for NMFS spring and fall surveys.

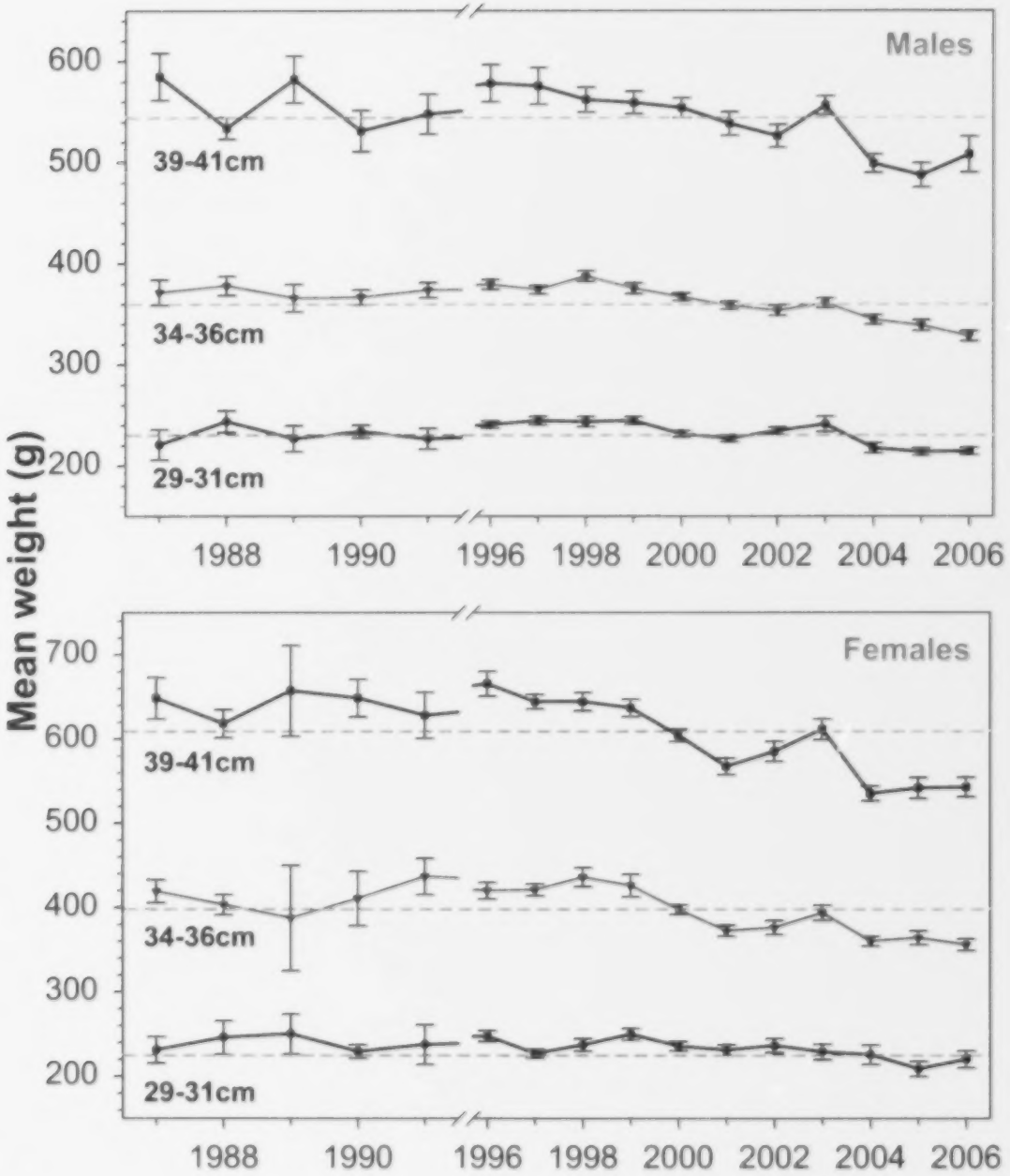



**Figure 19**. Trends in mean weight at 29-31cm, 34-36cm and 39-41cm cm TL for male and female yellowtail flounder sampled during February bottom trawl surveys conducted by DFO during 1987-1991 and 1996-2006. The dashed line is the long term mean for each series. Vertical bars represent ± 1SE.

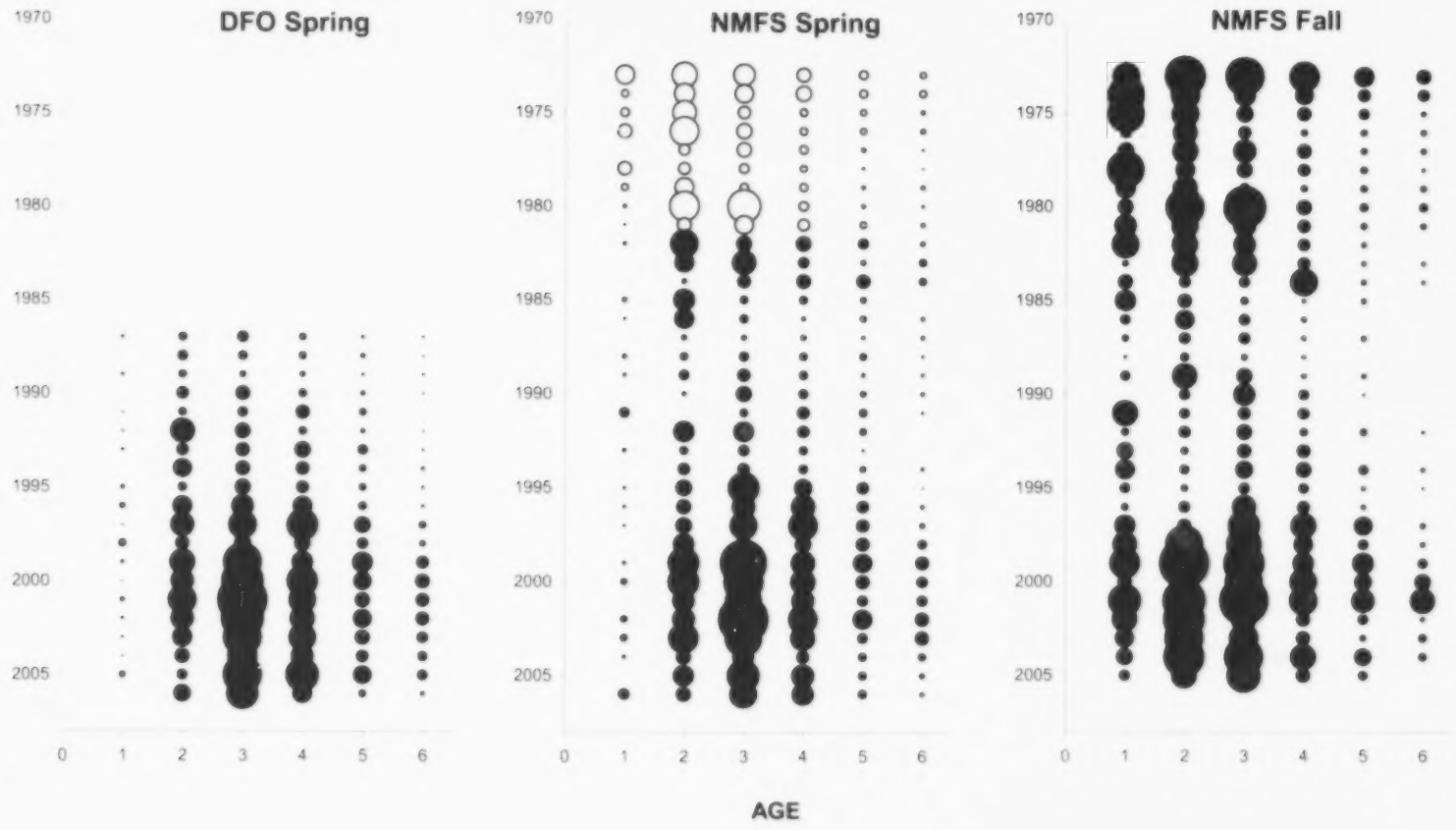



**Figure 20**. Age specific indices of abundance for the DFO spring (1987-2006), NMFS spring (1968-2006), and NMFS fall (1963-2005) surveys (bubble is proportional to the magnitude). The yellow symbols in the NMFS spring series denote the period when the Yankee 41 net was used. Age 6 denotes ages 6 and older. Refer to Tables 5, 6, and 7 for the specific values of the indices.

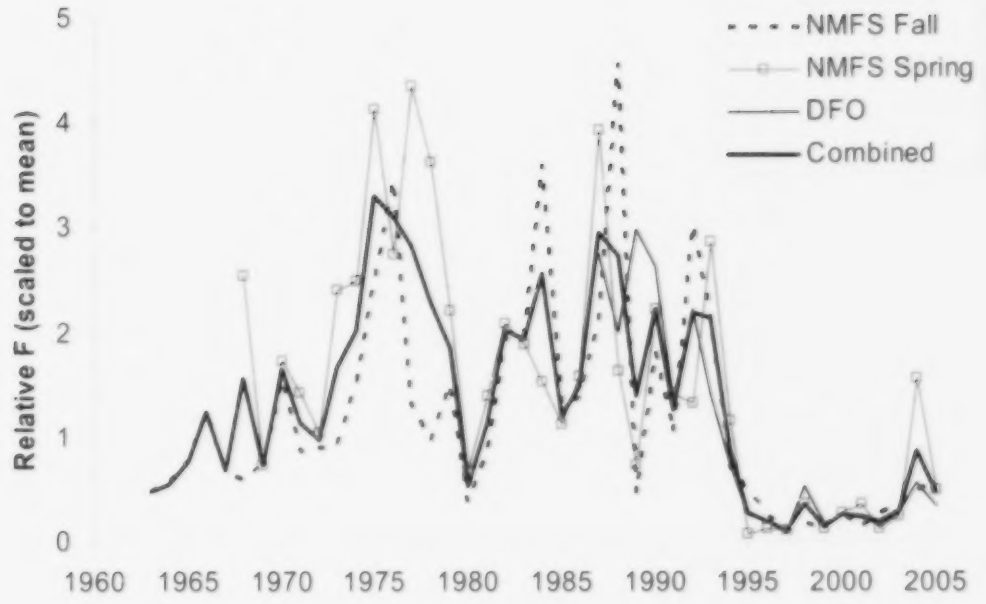



**Figure 21**. Trends in relative fishing mortality (catch biomass/survey biomass), standardized to the mean for 1987-2005. The combined line represents the average of the three surveys.

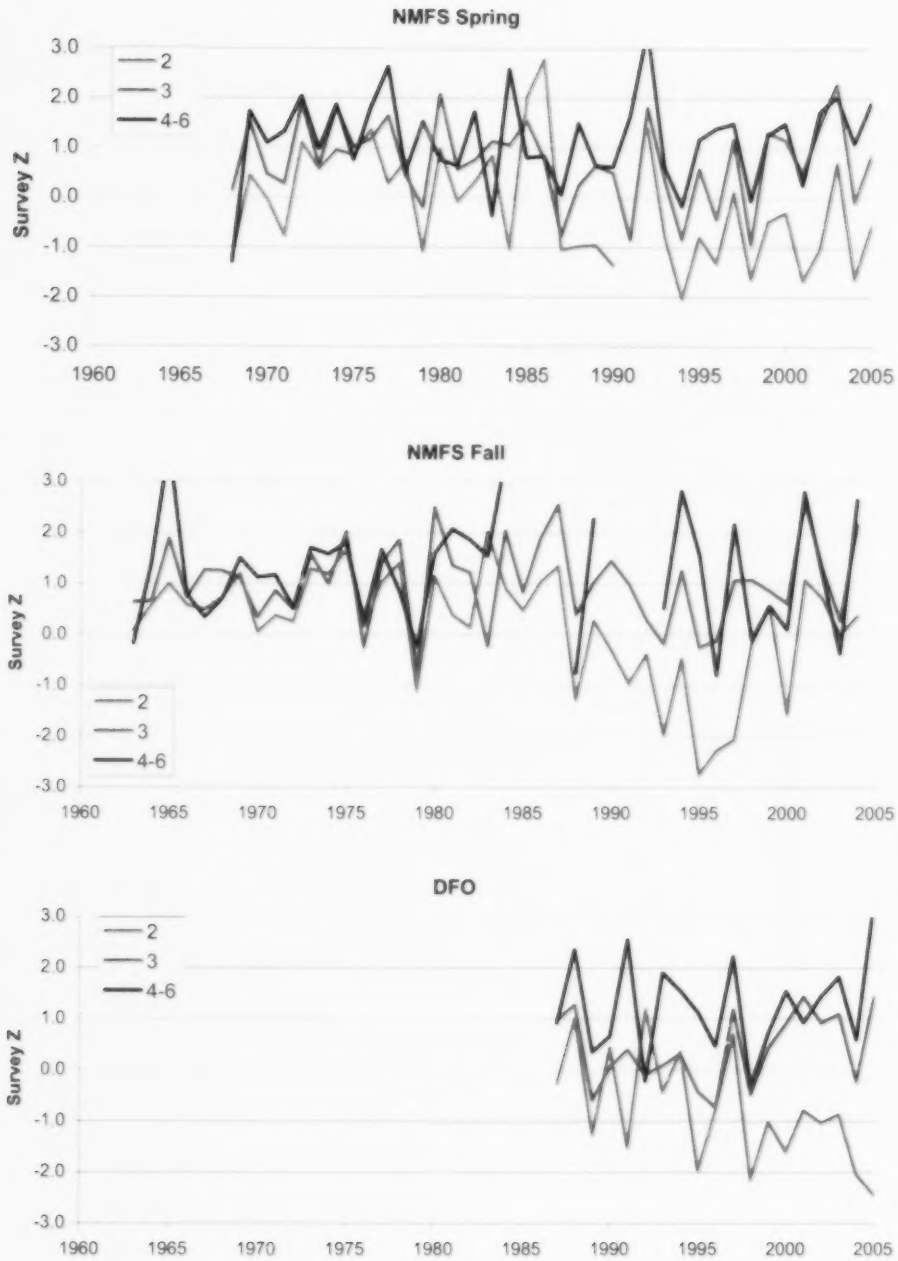



**Figure 22**. Trends in total mortality (Z) for ages 2, 3, and 4-6 from DFO, NMFS Spring and NMFS Fall bottom trawl surveys.

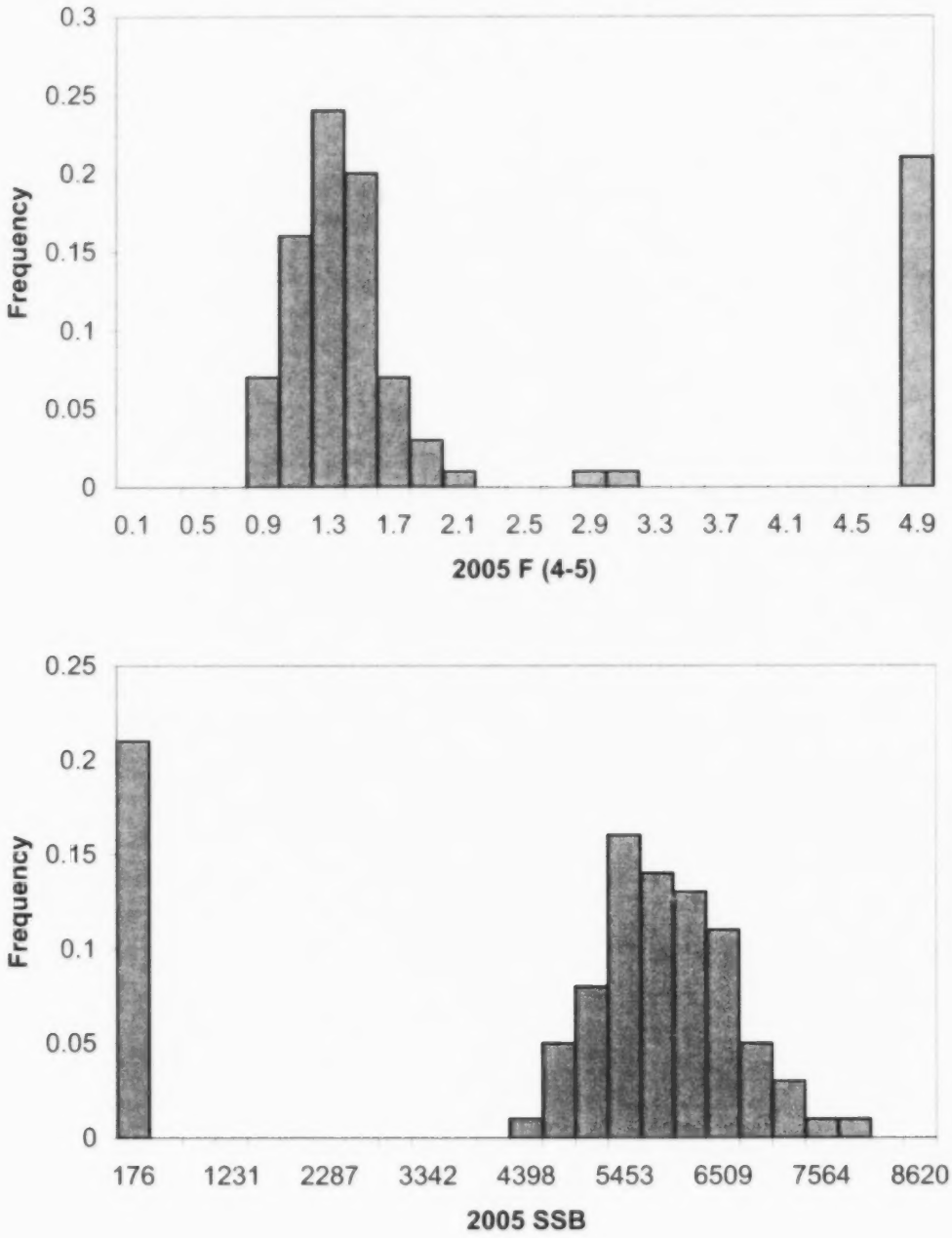



**Figure 23**. Bootstrap distributions of 2005 F ages 4-5 (top panel) and SSB (bottom panel) from the benchmark version Major Change VPA showing a bimodal distribution.

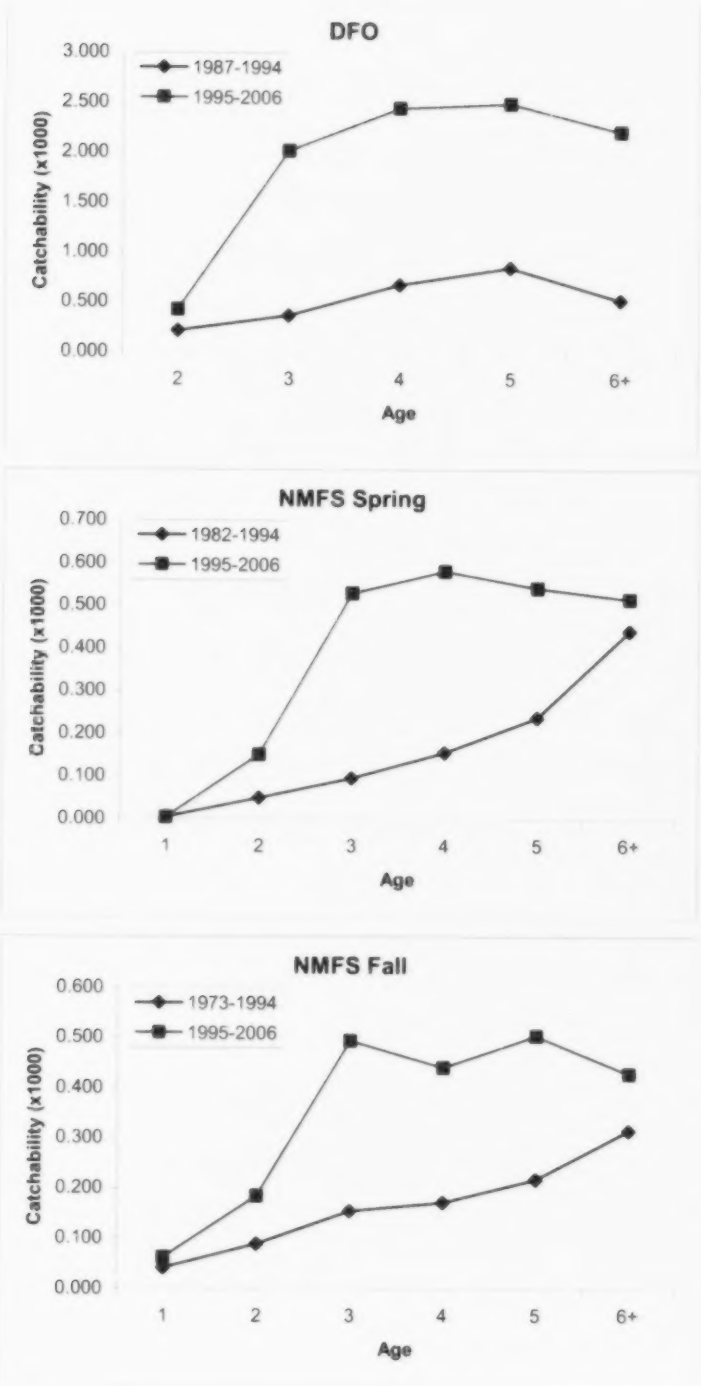



**Figure 24**. Catchability coefficients (q) from the Major Change VPA.

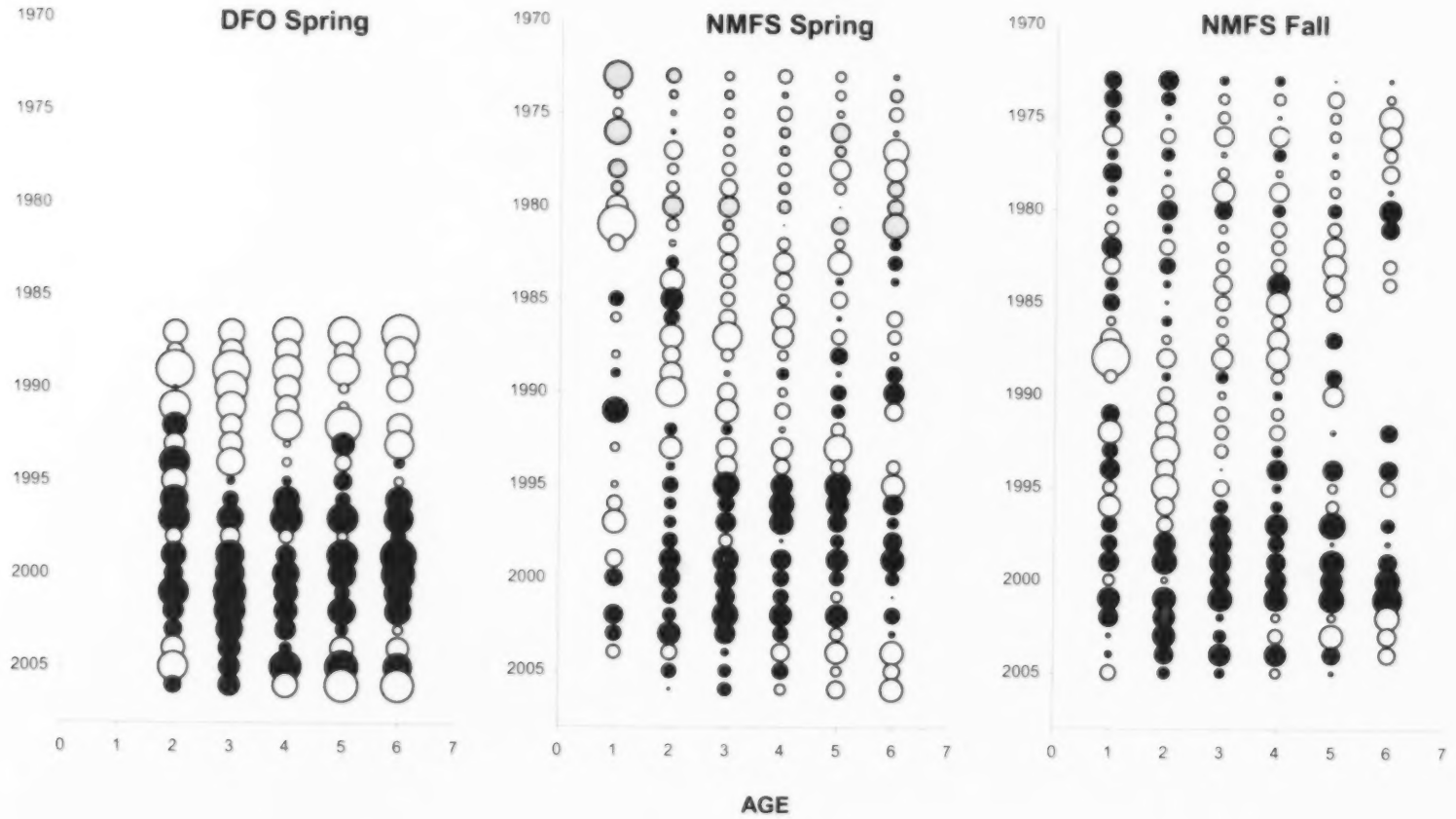



**Figure 25**. Age by age residuals from the Base Case VPA model formulation for *ln* abundance index minus *ln* population numbers, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The grey shaded symbols in the NMFS spring series denote the period when the Yankee 41 net was used. The open symbols denote negative residuals, and closed symbols denote positive residuals.

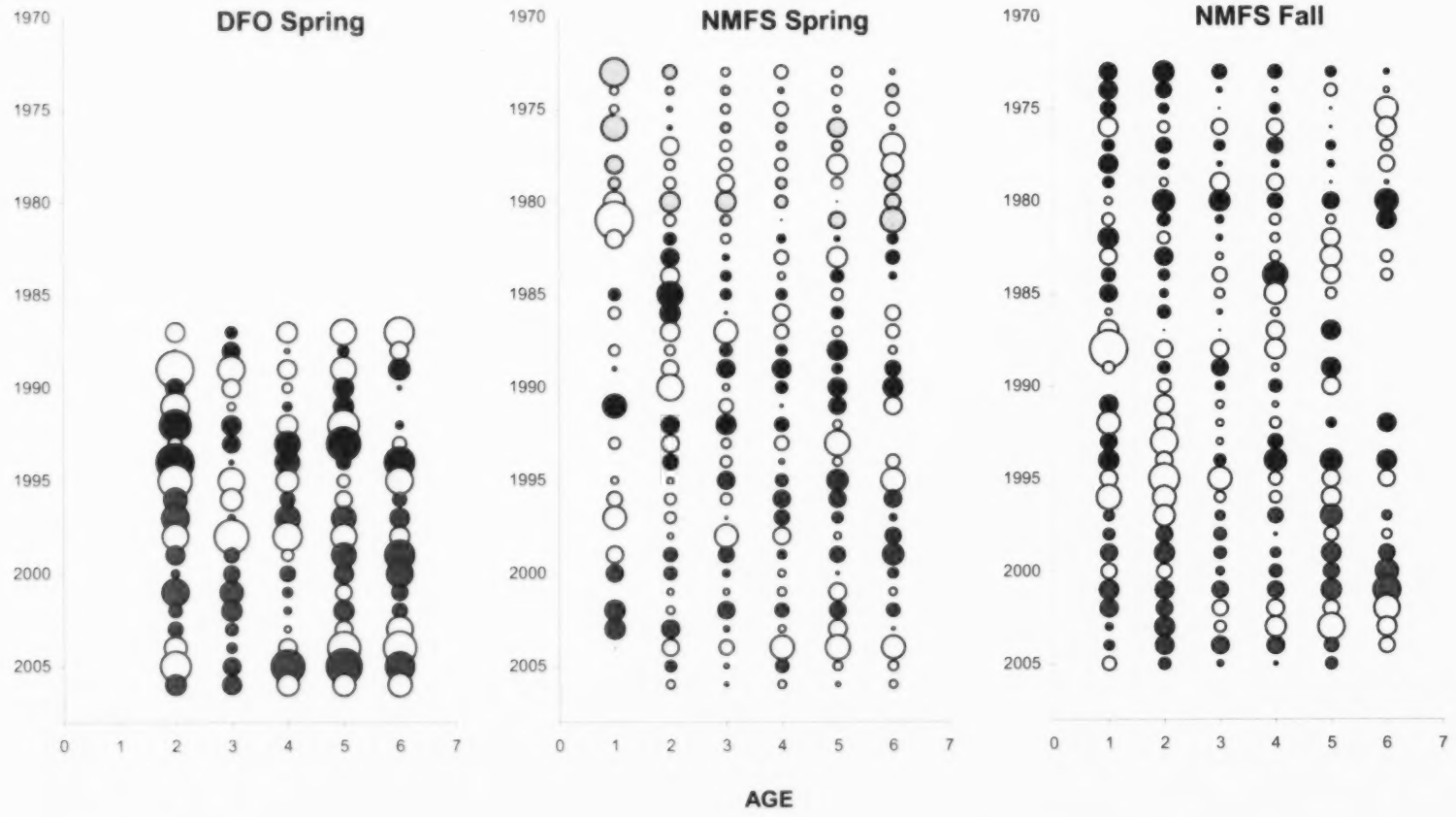



**Figure 26**. Age by age residuals from the Major Change VPA formulation for *ln* abundance index minus *ln* population numbers, Georges Bank yellowtail flounder (bubble size is proportional to magnitude). The different colors denote separate series. The open symbols denote negative residuals, and closed symbols denote positive residuals.

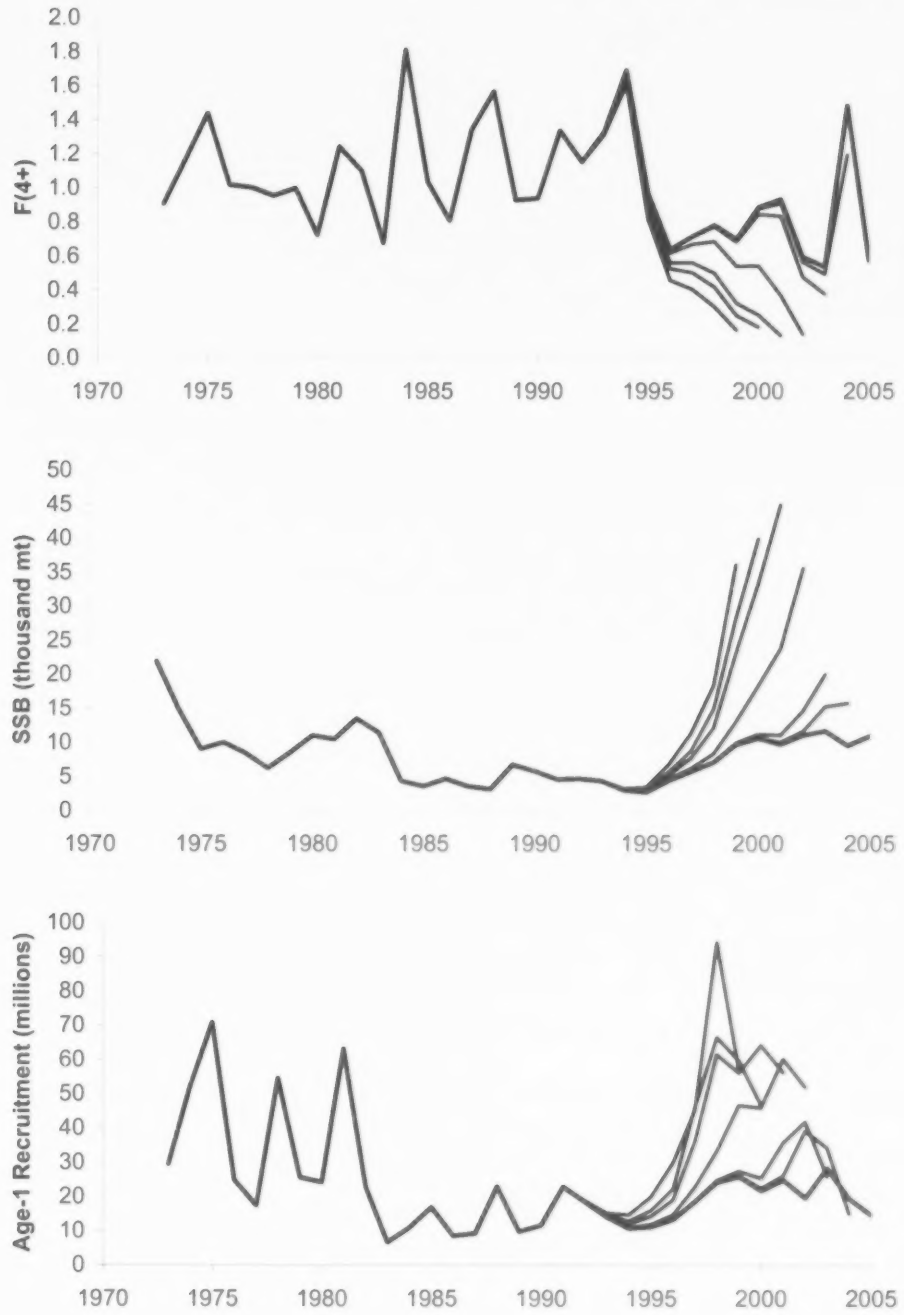



**Figure 27**. Retrospective analysis of Georges Bank yellowtail flounder from the Base Case VPA for ages 4+ fishing mortality (top panel), spawning stock biomass (middle panel) and age 1 recruits (lower panel).

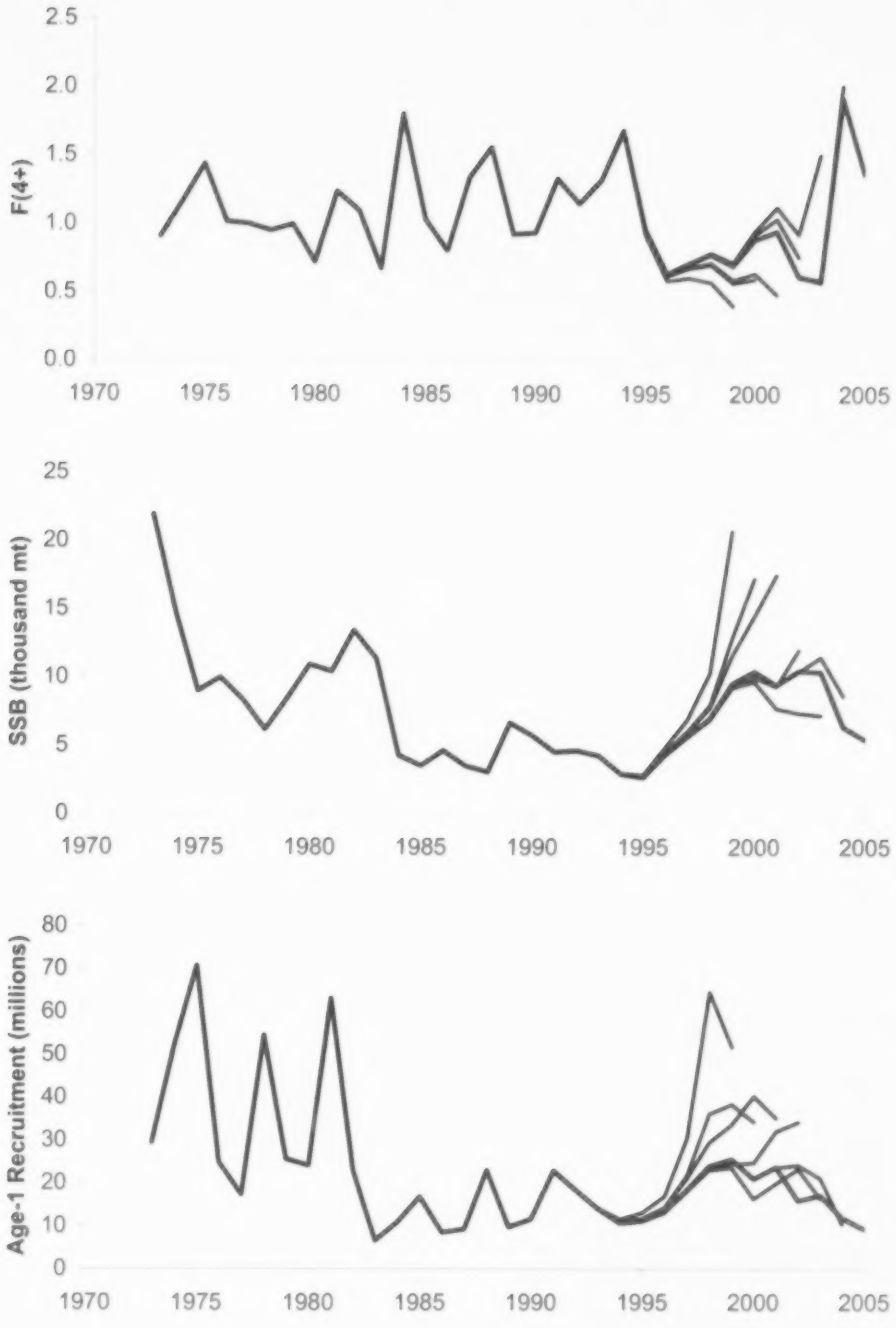



**Figure 28**. Retrospective analysis of Georges Bank yellowtail flounder from the Major Change VPA for ages 4+ fishing mortality (top panel), spawning stock biomass (middle panel) and age 1 recruits (lower panel).

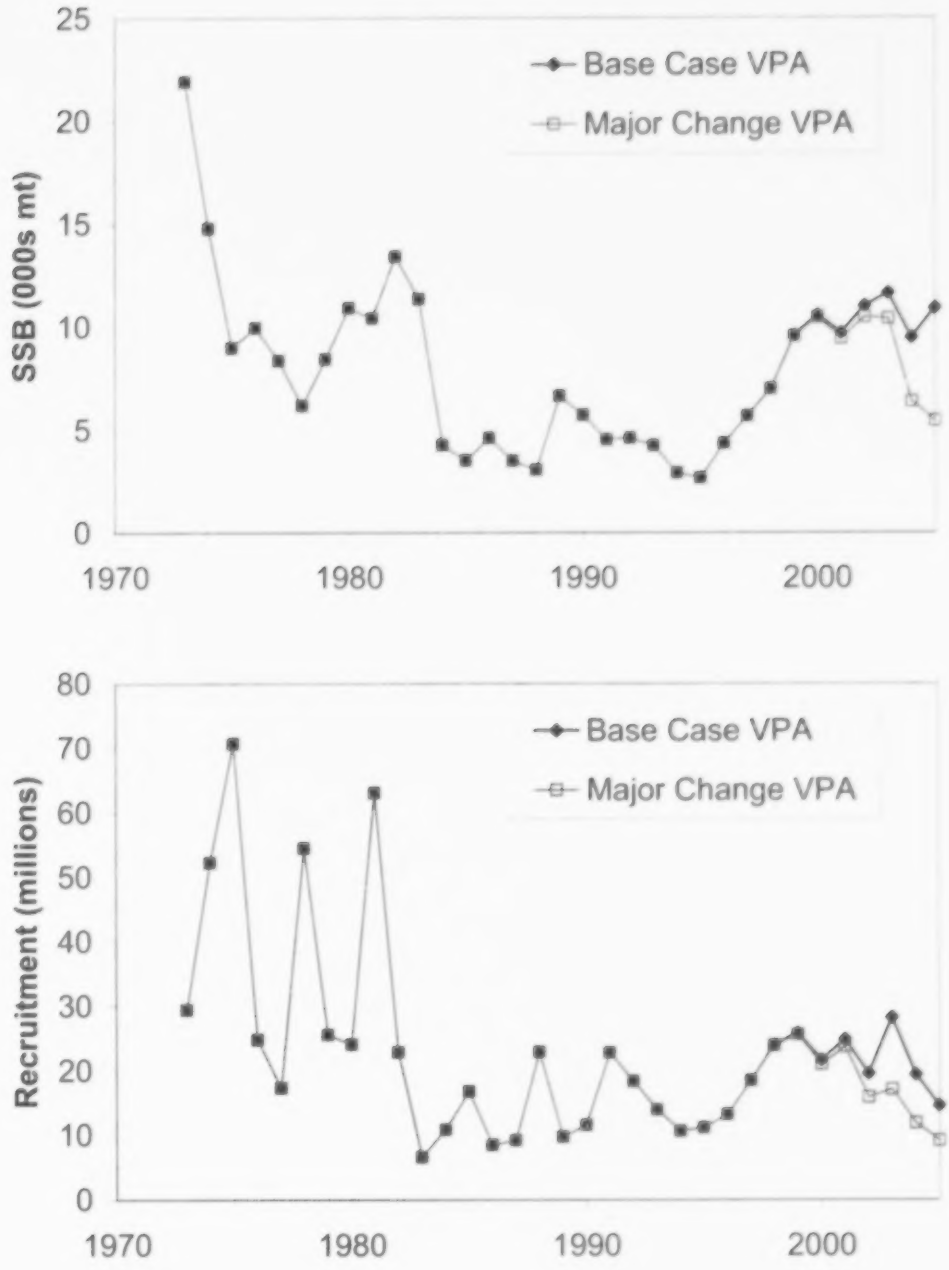



**Figure 29**. Trends in and spawning stock biomass and age 1 recruits for Georges Bank yellowtail flounder as indicated from the Base Case VPA and Major Change VPA. The Base Case VPA was rejected by the TRAC, it is presented here for comparative purposes only.

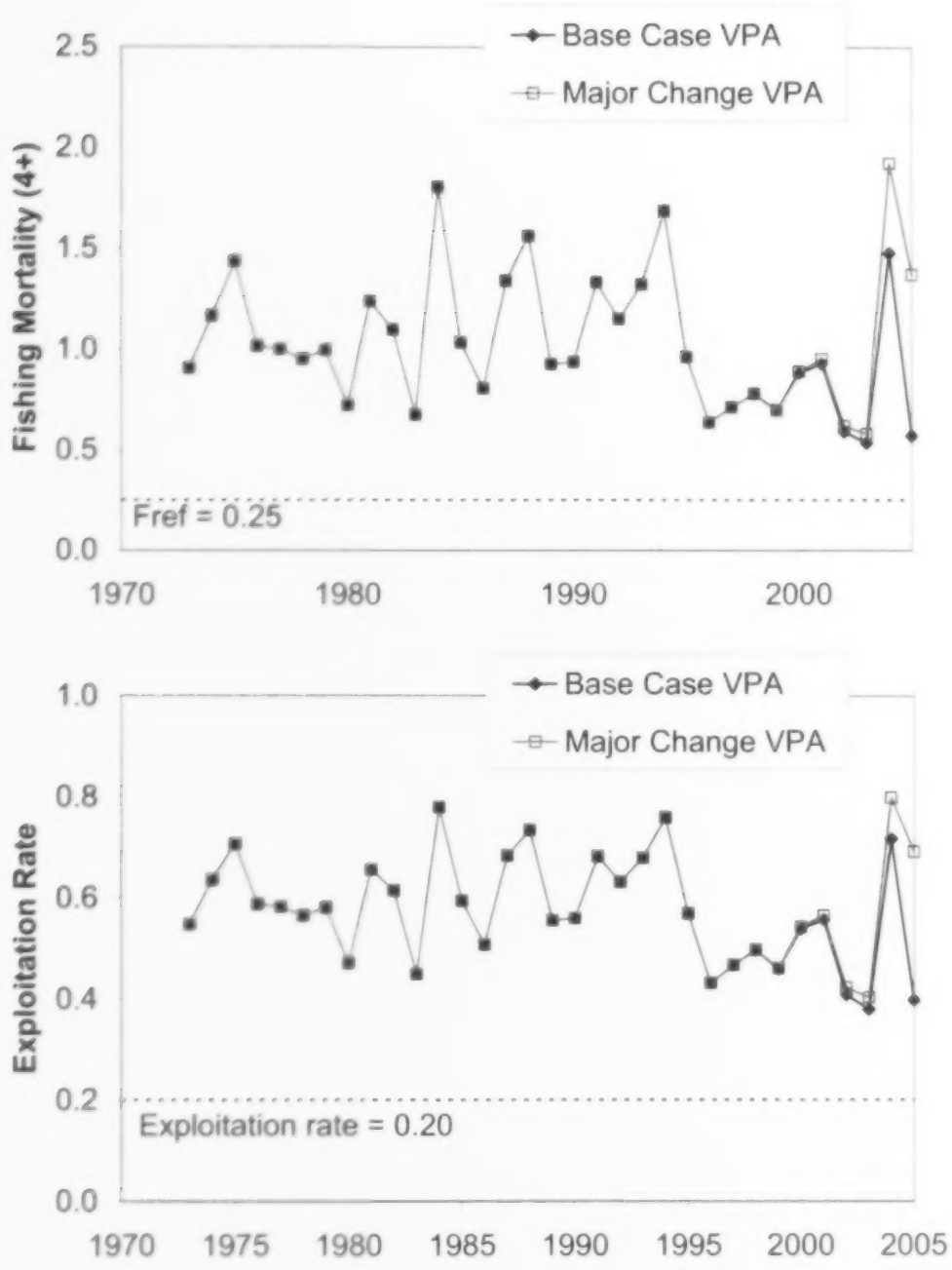



**Figure 30**. Trends in fully recruited (ages 4+) fishing mortality (upper panel) and exploitation rate (lower panel) for Georges Bank yellowtail flounder as indicated from the Base Case VPA and Major Change VPA. The Base Case VPA was rejected by the TRAC, it is presented here for comparative purposes only.

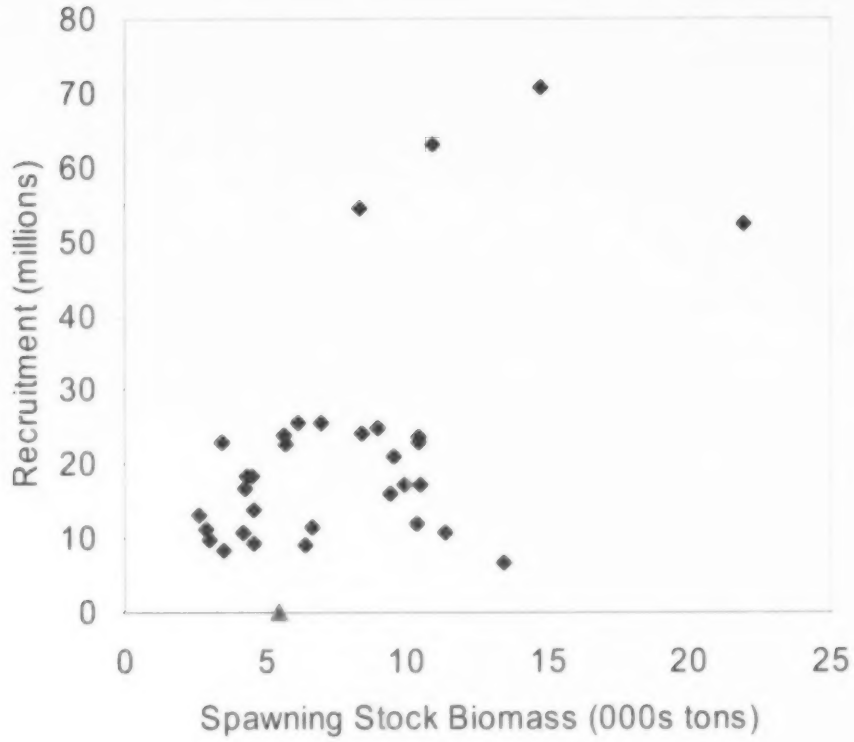



**Figure 31**. Spawning stock biomass and age 1 recruitment relationship for Georges Bank yellowtail flounder from the Major Change VPA formulation. The spawning stock biomass for 2005 (red triangle) is also shown on the x-axis.

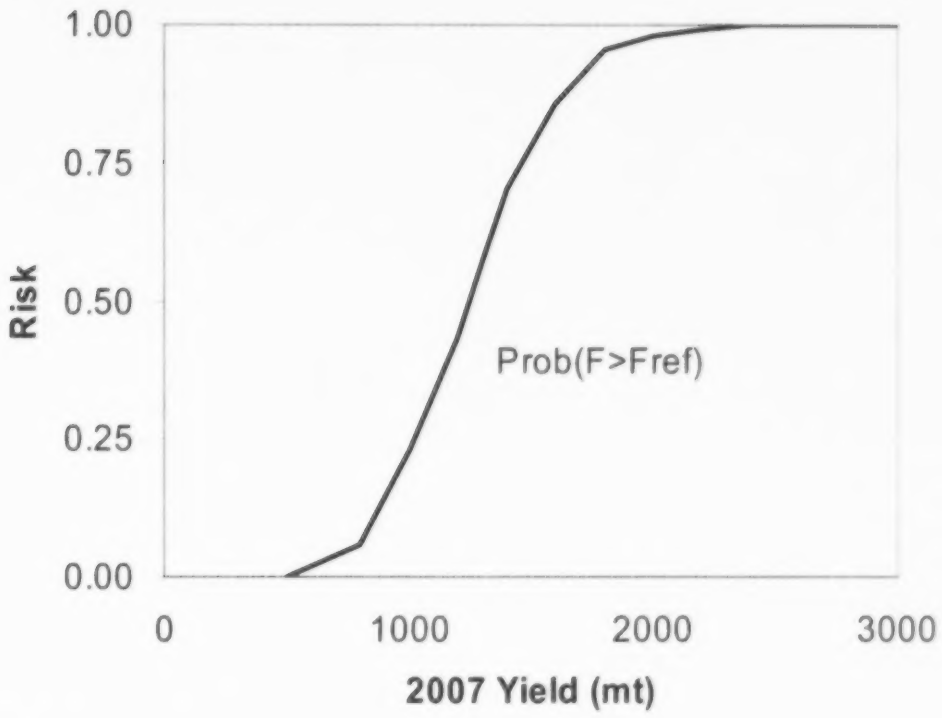



**Figure 32**. Risk of exceeding $F_{ref}$ fishing mortality from the Major Change VPA model formulation at various quotas for the 2007 fishery for Georges Bank yellowtail flounder.

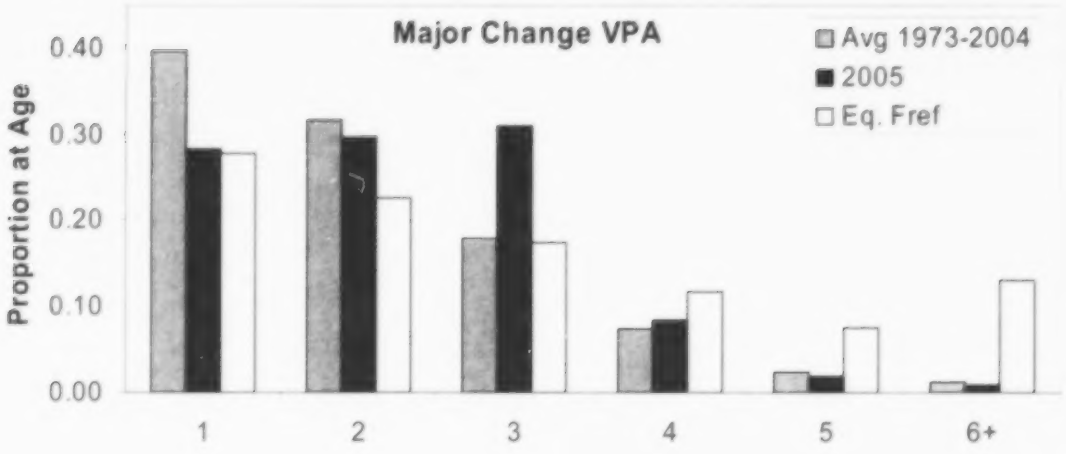



**Figure 33**. Proportions at age for the Georges Bank yellowtail flounder population in 2005, for the average of 1973-2004, and when the population is at equilibrium at the Fref of 0.25, based on results from the Major Change VPA.